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ABSTRACT

The topics of earthquakes and volcanoes are important to children but are often missing from elementary science textbooks. This document is a part of "The Natural Disaster Series" and is an attempt to supplement elementary science programs with lessons and student activities. Reasoning skills are also stressed throughout the document. Three questions follow each lesson's introductory information. These ask the student to: (1) think about cause and effect; (2) make a prediction based on the information in the selection; and (3) draw a conclusion which is supported by the evidence. These questions can be used by teachers for diagnosis, practice, or testing. Each lesson also involves an instructional activity which is intended to help make the content of that particular lesson more clear. It is suggested that the teacher present the vocabulary first, read and discuss the lesson as a class, do the activity, and then have the students re-read the lesson silently and answer the questions. A glossary is included which is indexed to the page numbers where each term is used. (TW)

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Earthquakes & Volcanoes

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A WORD TO THE TEACHER

THIS BOOK STRESSES REASONING SKILLS WITH A STRONG EMPHASIS ON SCIENCE CONTENT.

The first of the three questions at the end of each selection asks the student to **think about cause and effect.**

The second question asks the student to **make a prediction** based on information in the selection.

The third question asks the student to **draw a conclusion** which is supported by the evidence.

These questions can be used for diagnosis, practice, or testing.

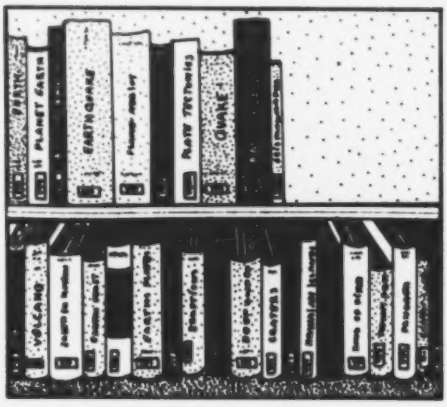
THIS BOOK DEALS WITH AN AREA OF SCIENCE IMPORTANT TO CHILDREN, YET CONSPICUOUSLY ABSENT FROM ELEMENTARY SCIENCE TEXTBOOKS.

To many of our children the prospect of a devastating earthquake is part of the structure of their lives. They need information about the forces at work so they can make some sense of this threat. Others live within sight of recently erupted volcanoes. Knowledge of the causes can help move children's attitudes from one of fatalism towards a confident "I can cope" outlook.

THE LESSONS ARE SEQUENTIAL, BUT SOME CAN BE OMITTED.

Lessons 5, 8, 9, 12, and 13 give an outline of plate tectonics and continental drift and explain briefly the causes of volcanoes and earthquakes. To be most easily understood, these particular lessons should stay in order. Other lessons can be added according to the interests of you and your class.

The activity on the back of each lesson is designed to make the content of that particular lesson clear. The most fruitful sequence is to present the vocabulary (see Lesson Notes, pages iv, v, and vi), read and discuss the lesson as a class, do the activity, then have the children re-read the lesson silently and answer the questions.



NEW BOOKS ARE COMING OUT ALL THE TIME.

This is an active area for both scientists and publishers. You will find books on earthquakes, volcanoes, and plate tectonics in your school library under the Dewey Decimal number 551. Look at the copyright dates; most of the books you will find useful have been printed since 1973.

A film that you may want to show after your students have had at least the basic lesson is *Volcanoes, Earthquakes and Other Earth Movements*, distributed by Journal Films, copyrighted in 1981.

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LESSON NOTES

Lessons 1 and 2: MYTHS ABOUT EARTHQUAKES AND VOLCANOES

Classic myths can be found in your library under the Dewey Decimal number 291. One problem is that many of the same stories are told, sometimes using the Greek and other times the Roman names for the gods. Jupiter, Juno, and Vulcan, for instance, are Roman names for the Greek gods Zeus, Hera, and Hephaestus. If you use myths for read-alouds in connection with these lessons, you will need to explain or correct for this.

Writing a used-to-think story (Lesson 1) comes easily to many children. Writing an explanatory myth (Lesson 2) comes harder. You may want to make this a group or committee rather than an individual project.

Lesson 1 vocabulary found in the glossary: Atlas, earthquake, Greeks, Hercules, Hindu, myths, Titans, tortoise, Zeus

Lesson 1 answers: 1. b 2. c 3. a

Lesson 2 vocabulary found in the glossary: anvil, blacksmith, erupt, forge, Juno, Jupiter, myth, volcano, Vulcan, Vulcano

Lesson 2 answers: 1. b 2. b 3. a

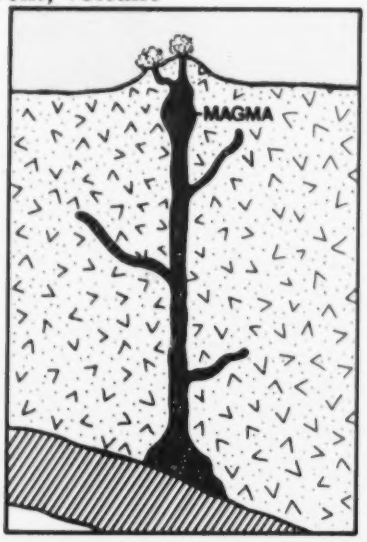
Lessons 3, 4, and 5: THE ANATOMY AND PHYSIOLOGY OF VOLCANOES.

Coloring sheets on the back sides of these lessons all reinforce the information in Lesson 3. You may want to compare and contrast them before doing the questions on Lesson 3.

To illustrate the role of dissolved gas in making magma explosive (Lesson 4), you can compare what happens when you shake and open bottles or cans of noncarbonated orange juice and carbonated orange pop.

Warning: Your school may still have a dichromate volcano model. The chemicals used in this model are now considered too hazardous to use in elementary schools.

Lesson 3 vocabulary found in the glossary: andesite, basalt, cinder cone, composite cone, crater, lava, Mt. McKinley, Mt. St. Helens, shield volcano, vent, volcano



Lesson 3 answers: 1. b 2. a 3. c

Lesson 4 vocabulary found in the glossary: andesite, basalt, cinder cone, erupt, lava, magma, shield volcano, volcano

Lesson 4 answers: 1. b 2. b 3. c

Lesson 5 vocabulary found in the glossary: crater, erupt, lava, magma, Mt. Shasta, Mt. St. Helens, Shastina, volcano

Lesson 5 answers: 1. b 2. b 3. c

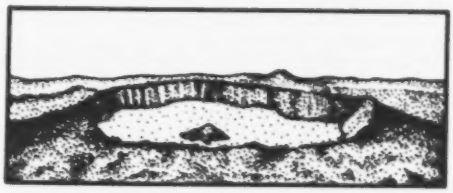
Lesson 6: CRATER OR CALDERA: THE FORMATION OF CRATER LAKE

The formation of a caldera is hard for students to understand without an animation. The flip book should therefore be made and discussed after a first and before a second reading. This activity should not be omitted.

Lesson 6 vocabulary found in the glossary: caldera, cinder cone, Crater Lake, erupt, lava, magma, Mt. Mazama, volcano, Wizard Island

Lesson 6 answers: 1. c 2. c 3. b

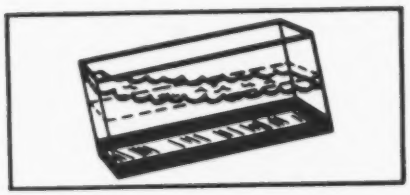
Lesson 7: PREDICTING ERUPTIONS



Paricutin is pictured in most books on volcanoes, both as it looks today and as it was forming. Look in your school library among the volcano and earthquake books (Dewey Decimal 551.2).

Children are fascinated by the idea that animals seem to sense volcanoes and earthquakes before they occur. You may want to get *When the Snakes Awake* by Helmut Tributsch from your public library for the documentation (Dewey Decimal 001.94T).

The idea of a tiltmeter can be demonstrated by marking water level in a rectangular aquarium and then slightly raising one end of the table on which it sits and marking the new water level.

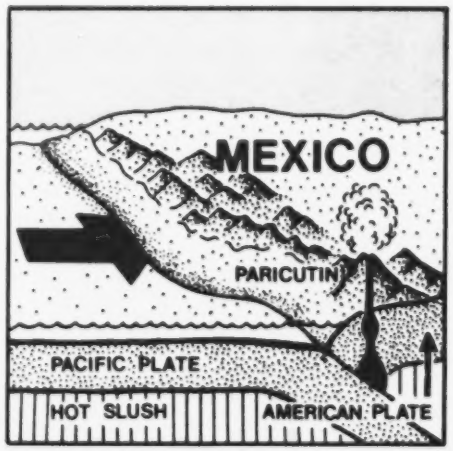


Lesson 7 vocabulary found in the glossary: cinder cone, earthquake, erupt, lava, magma, Mt. Baker, Paricutin, tiltmeter, vent, volcano

Lesson 7 answers: 1. c 2. a 3. b

Lessons 8—14: THE STRUCTURE OF THE EARTH: PLATE TECTONICS

The Time-Life books *Volcano* (Dewey Decimal 551.21V) and *Continents in Collision* (Dewey Decimal 551.136) have excellent illustrations related to these lessons. Children are fascinated by these illustrations. The reading, however, is college level.



Lesson 8 vocabulary found in the glossary: crust, earthquake, molten, slushy layer

Lesson 8 answers: 1. a 2. a 3. b

Lesson 9 vocabulary found in the glossary: Antarctic, Arctic, crust, earthquake, magma, plate, slushy layer

Lesson 9 answers: 1. c 2. b 3. a

Lesson 10 vocabulary found in the glossary: crust, earthquake, Fuji, Marianas Trench, Mt. Everest, plate, Ring of Fire, trench, volcano

Lesson 10 answers: 1. c 2. a 3. b

Lesson 11 vocabulary found in the glossary: basalt, crust, geyser, hot spots, Kauai, Kilauea, lava, Maui, Mauna Loa, Molokai, Mt. Mazama, Mt. St. Helens, Oahu, Pacific Plate, plate, shield volcano

Lesson 11 answers: 1. c 2. b 3. c

Lesson 12 vocabulary found in the glossary: Alps, andesite, basalt, granite, Himalayas, Pangaea, plate

Lesson 12 answers: 1. b 2. c 3. a

Lesson 13 vocabulary found in the glossary: basalt, earthquake, fault, plate, slush, tectonic plate, trench, volcano

Lesson 13 answers: 1. b 2. b 3. a

Lesson 14 vocabulary found in the glossary: North American Plate, caldera, earthquake, erupt, magma, Pacific Plate, San Andreas Fault, tectonic plate, volcano

Lesson 14 answers: 1. c 2. a 3. c

Lesson 15: MEASURING EARTHQUAKES

These two lessons are intended for sixth graders or advanced fifth graders.

The demonstration described in the second paragraph of Lesson 15 is important to student understanding of how the pen on a seismograph can stay still while everything around it, including the paper it is drawing on, moves. A student can prepare the demonstration as a homework assignment.

The Human Seismograph activity on the back can also be done as a demonstration. Preparing for it can be a homework assignment for two friends. When the class has seen it done, their own simulations will be more fruitful and less chaotic.

Lesson 15 vocabulary found in the glossary: earthquake, seismologist, seismogram, seismograph, trace

Lesson 15 answers: 1. b 2. c 3. c

Lesson 16: TSUNAMI—THE GREAT WAVES

Your students will need to see the Tsunami Travel Times chart on page 38 to discuss or answer question 2. An overhead transparency will serve the purpose.

Notice that the plural of tsunami is the same as the singular: one tsunami, several tsunami.

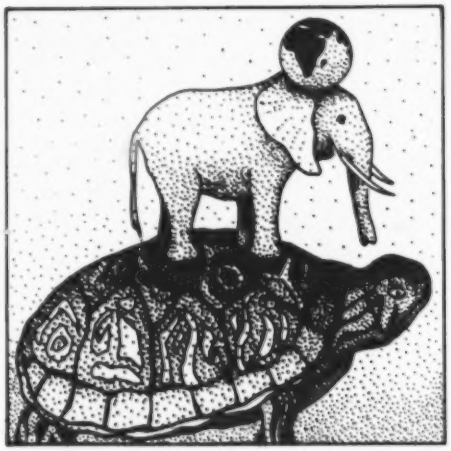
Lesson 16 vocabulary found in the glossary: earthquake, seismologist, Tsunami, Tsunami Warning System

Lesson 16: 1. c 2. b 3. b

LESSON 1

Name _____

TWO MYTHS ABOUT EARTHQUAKES



People have always wondered about the world around them. Before they knew much about science, people explained things to each other in stories. MYTHS are stories told to explain something about the world.

A long time ago the HINDU people, who lived in India, believed that the earth rested on the head of an elephant. The elephant sat on the back of a tortoise. When either one of the animals moved, the earth shook, and that made an earthquake.

The Greeks of long ago had a myth about a race of gods called Titans who went to war with another race of gods led by Zeus. One of the Titans was named Atlas. After the other gods won the war, Zeus punished Atlas for fighting against him by making him hold up the earth on his shoulders forever. Atlas was strong enough to do this, but sometimes he had to move the load around on his shoulders to get more comfortable. When he did this the earth shook, making an earthquake.

1. In the Greek myth about Atlas, an earthquake happens because
   a. the gods are fighting.
   b. Atlas moves the earth around on his shoulders.
   c. Atlas drops the earth.

2. Atlas had a strong friend named Hercules. Once Hercules offered to hold up the earth for a while so that Atlas could do an errand for him. Atlas probably
   a. refused.
   b. told Hercules to come back the next day.
   c. gave the earth to Hercules right away and then took a long time to do the errand.

3. We can tell from the Hindu myth that
   a. most Hindus have seen tortoises and elephants.
   b. elephants and tortoises like each other.
   c. tortoises are bigger than elephants.

Name _____

A USED-TO-THINK STORY

Did you used to think that trees made the wind by waving their branches? Many children think that when they are very small.

Did you used to think that all cats are girls and dogs are boys? That's another thing that many small children believe.

Can you remember some of the other things you used to believe that you now know aren't so? Maybe you can talk it over with a neighbor and compare ideas you used to have. Maybe the teacher will let several boys and girls tell the class about ideas they used to have.

On the lines below write several sentences or a paragraph about something you used to think. If you can't remember, it's all right to make something up. Maybe you could make up a story about where a baby thinks the rain comes from.

Be sure that you indent the first line and that you start each sentence with a capital letter and end it with the right punctuation.

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LESSON 2

Name _____

A MYTH ABOUT VOLCANOES

Vulcan was the Roman god of fire. He was a son of Jupiter and Juno, who were king and queen of the gods. His parents got angry at him and threw him out. He fell for a whole day before he landed on Earth, and he was lame for the rest of his life. He never went back to live with the other gods. Instead, he learned to be a blacksmith and did a lot of work for them in his underground workshops. He made swords, spears, helmets, shields, and armor for them. There were a lot of gods and they did a lot of fighting, so this kept him pretty busy. He also made thunderbolts for Jupiter to hurl about during thunderstorms.

Vulcan kept helpers busy at several underground workshops. He worked sometimes at one, sometimes at another. The work went a lot faster where he was working with his helpers. Then there was likely to be a lot of underground rumbling, because Vulcan beat the iron on the anvils so hard. Iron must be heated in super-hot fires called FORGES before it can be beaten into shape on an anvil. Many Romans thought that volcanoes were the chimneys above these super-hot forges where Vulcan heated his iron. When a volcano erupted and poured out lava and ash, the Romans nearby decided that the god Vulcan was at work there. One of the volcanoes was named after him—Vulcano. The map shows Vulcano and several other volcanoes.

1. People in villages near a volcano were sometimes in danger from lava and hot ash. They thought this was because
   a. the inside of the earth was hot.
   b. Vulcan's workshop was under the volcano.
   c. the gods were angry at them.

2. When Vulcan left one volcano to work under another
   a. the first volcano erupted harder than before.
   b. the first volcano stopped erupting.
   c. Jupiter started hurling thunderbolts.

3. We can tell from this story that the Romans
   a. knew how to forge iron.
   b. were afraid of the gods.
   c. lied about volcanoes.

Name _____

YOUR OWN MYTH

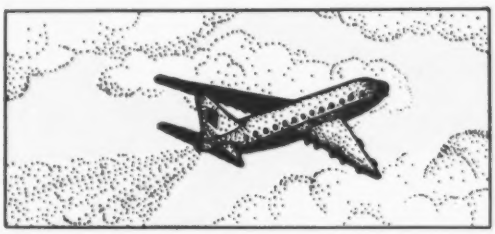
People all over the world have invented myths to try to help each other understand how things around them came to be the way they are. The story about Atlas causing earthquakes when he moved the earth about on his shoulders is a myth. So is the story about Vulcan working in different workshops where volcanoes were the chimneys over his hot forges.

Some authors have used myth-like stories without expecting anyone really to believe them. What they told were just good stories. Maybe you know Kipling's "How the Elephant Got His Trunk" from *Just So Stories.* That is one of several stories that Kipling wrote using the myth form.

Can you think of a myth-like reason for something and put it in a story? You could write about why dogs wag their tails when they're very happy. It could be because the Creator saw that smiles wouldn't be very useful in the tall grass where dogs lived, so he gave them tails to wave high above the grass-tops instead.

Perhaps you could write a story about why airplanes leave contrails behind them. It could be because a naughty jet once tried to hide so it wouldn't have to do so much work, and then the other planes got together and hired a little cloud to follow after the jet. Then they could always find it when there was work to be done.

Write your myth on the lines below. Be sure that you indent the first line and that you end each sentence with the right punctuation.

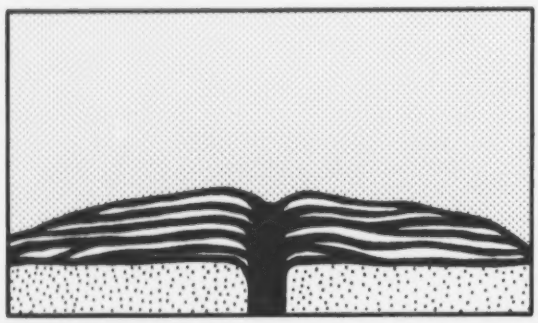


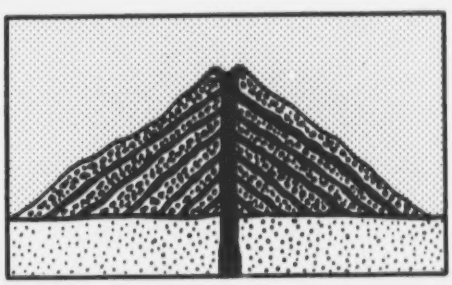
LESSON 3

Name _____

THREE KINDS OF VOLCANOES

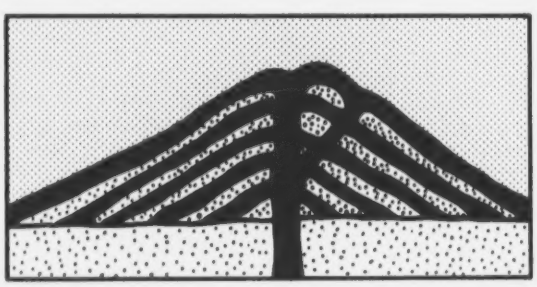
SHIELD VOLCANOES have gentle slopes, like a shield, because they are made of many layers of a kind of volcanic rock that flows easily when melted. This kind of rock is called BASALT. When it flows out of the vent it forms thin layers sloping away from the crater. Some shield volcanoes get to be very large. The volcanoes which make up the islands of Hawaii are shield volcanoes.





CINDER CONES are made of bits of a kind of volcanic rock called ANDESITE. Sometimes there are bits of basalt, too. These bits of rock are called cinders. They may be tiny, like ash, or larger, like gravel. They get blown out of the vent and harden in the air. When they land, they pile up around the crater to form a steep cone. Cinder cones are often smaller than shield volcanoes, and they wear away easily.

COMPOSITE CONES are made of layers of cinders between layers of lava. The layers of cinders make the sides steep, and the layers of hardened lava keep them from wearing away fast. Many famous volcanoes like Mt. St. Helens in the state of Washington are composite cones.



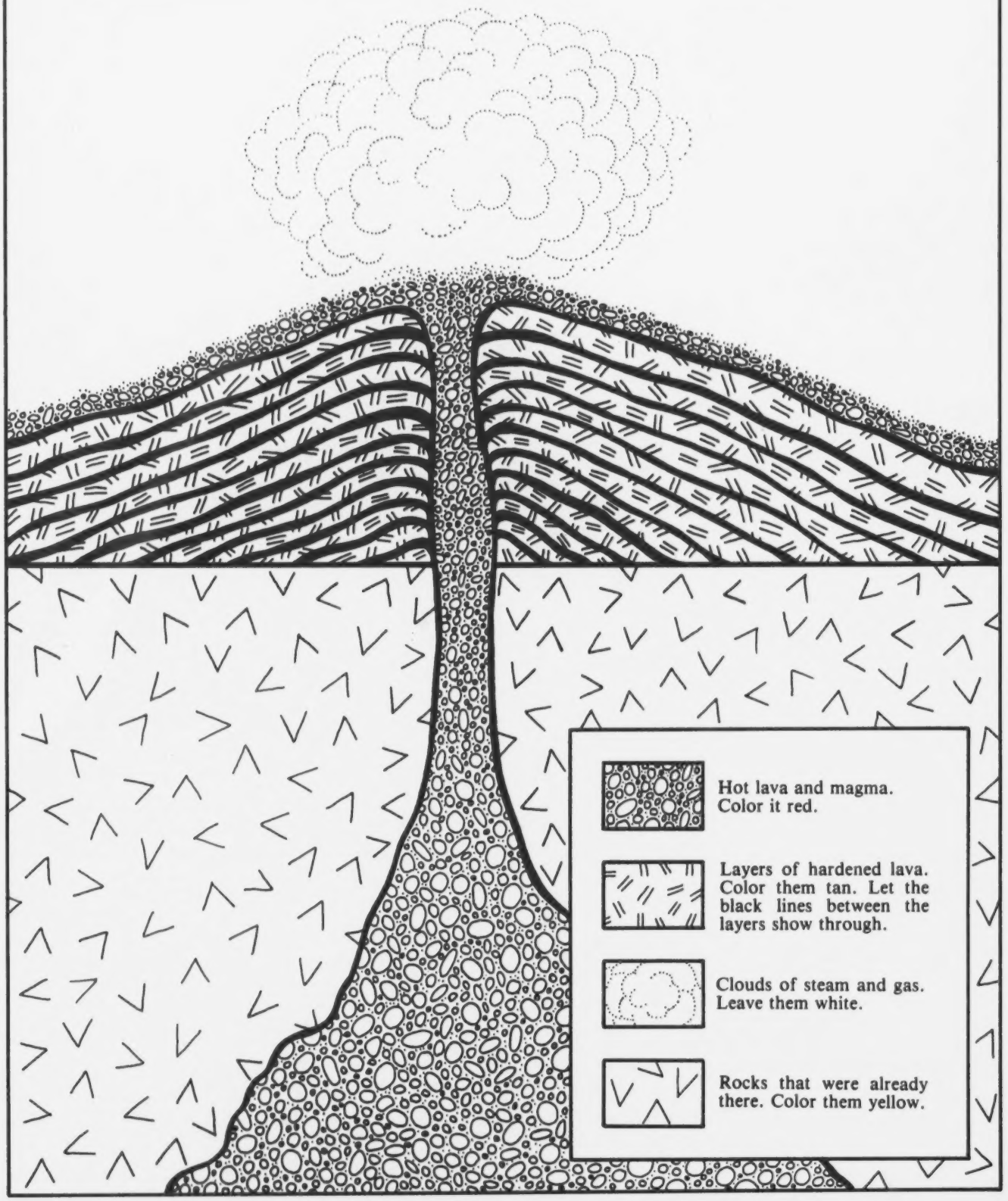
1. Composite cones are often bigger than cinder cones because
   a. they are older and have had more time to grow.
   b. the hardened lava keeps them from wearing away fast.
   c. they grow where there are already mountains.

2. After a shield volcano erupts, it usually is
   a. a little higher because most of the lava runs down the sides of the volcano.
   b. a lot higher because most of the lava piles up around the vent.
   c. lower because the top of the volcano will cave in.

3. Mt. McKinley in Alaska is one of the world's highest volcanoes. From its size we can tell that
   a. everything in Alaska is big.
   b. Mt. McKinley is a cinder cone.
   c. Mt. McKinley is not a cinder cone.

Name _____

A SHIELD VOLCANO


Hot lava and magma. Color it red.
Layers of hardened lava. Color them tan. Let the black lines between the layers show through.
Clouds of steam and gas. Leave them white.
Rocks that were already there. Color them yellow.

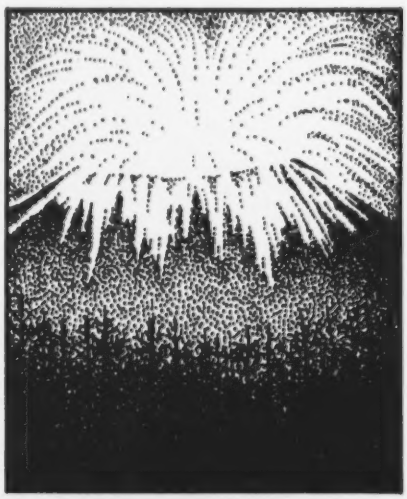
LESSON 4

Name _____

WHAT MAKES VOLCANOES EXPLODE?

When you look at the pop in an unopened bottle, you can see a few bubbles of gas in it, but not many. Shake the bottle and take off the pressure cap. Out come thousands of bubbles bringing a shower of liquid with them. The pressure kept the gas dissolved in the liquid. When you took off the cap, the pressure of the gas made it suddenly come out of solution and explode out of the bottle.

The hot magma underneath volcanoes has a lot of gas dissolved in it, too. The rocks on top press down and keep the gas dissolved. Then when something takes the rocks away, the gas suddenly comes out of solution and explodes out of the volcano. Rocks and hot lava come with it.



EXPLODING CINDER CONE

Cinder cones are more dangerous than shield volcanoes because the magma under cinder cones is made mostly of a kind of rock called ANDESITE which can dissolve a lot of gas. This makes cinder cones very explosive. The magma under shield volcanoes, like those in Hawaii, is made mostly of a kind of rock called BASALT which can dissolve only a little gas. This makes shield volcanoes less explosive. When shield volcanoes erupt, people have time to get out of the way because the magma doesn't explode. It flows.

EXPLODING POP BOTTLE

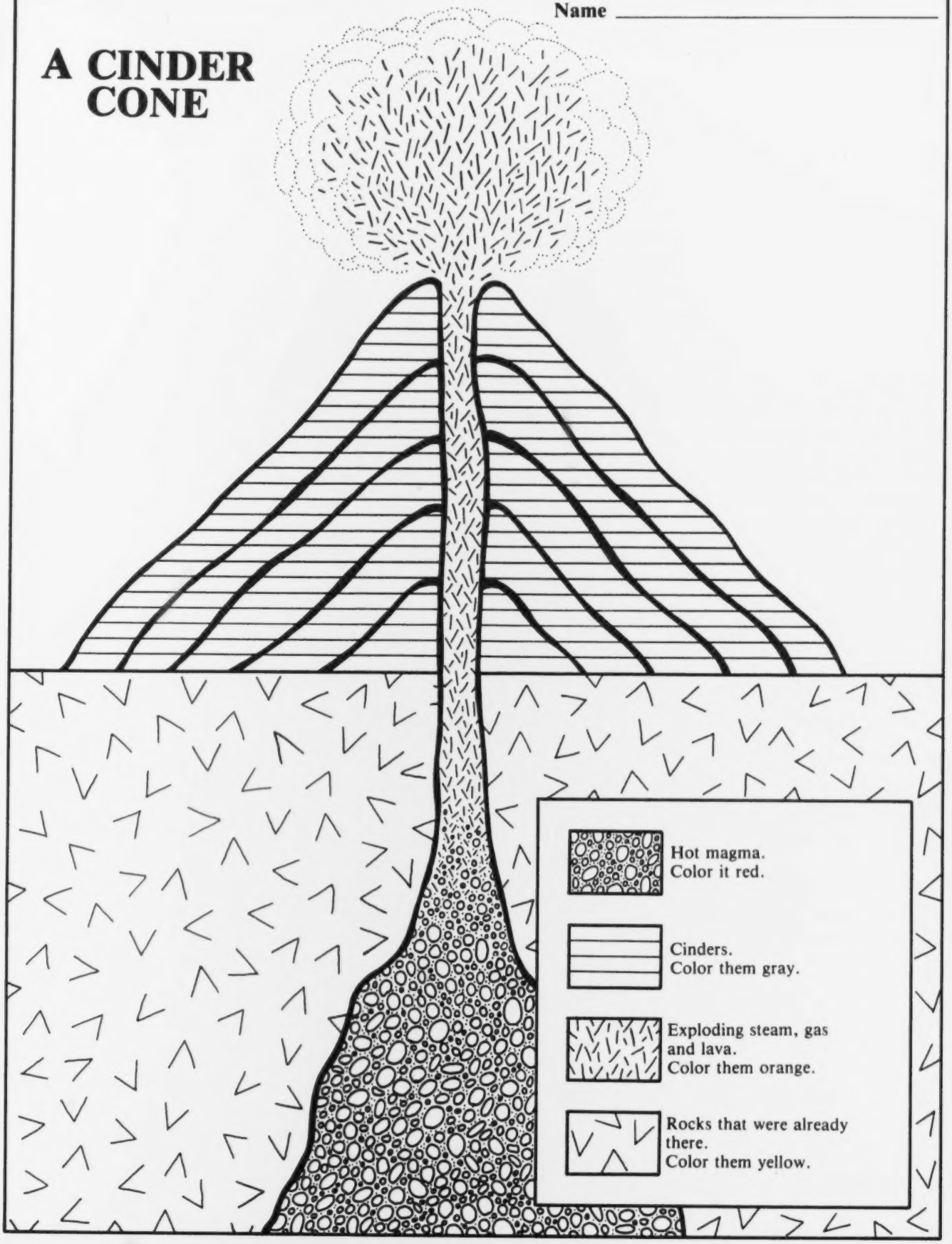
1. Cinder cones are more explosive than shield volcanoes because
   a. the magma under them can't absorb much gas.
   b. the magma under them can absorb a lot of gas.
   c. the magma under them is hotter than the magma under shield volcanoes.

2. When the magma under a volcano is mostly andesite, the lava that comes out during an eruption will
   a. flow out.
   b. explode out.
   c. bubble out.

3. From the story you can tell that
   a. pop got its name from the way it pops out.
   b. there are more cinder cones than shield volcanoes on earth.
   c. cinder cones are different from shield volcanoes because the magma under them dissolves gas differently.

Name _____

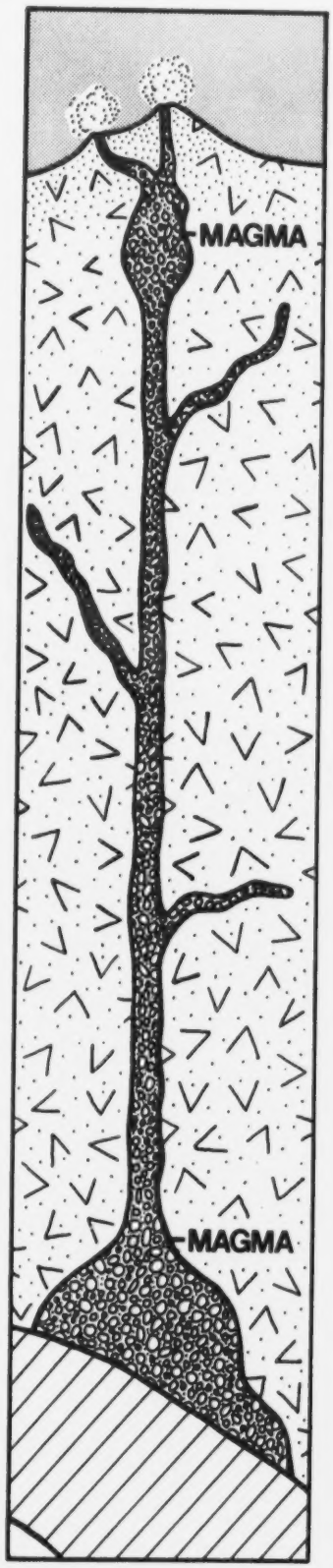
A CINDER CONE



LESSON 5

Name _____

DEEP UNDER A VOLCANO



No one can dig under a volcano to see what is underneath, but scientists who study volcanoes have learned many ways to make guesses and check them out. Many scientists agree that deep underground there is rock so hot that it is melted. This melted rock is under so much pressure from all of the rocks above that it is pushed up through cracks toward the surface of the earth.

The melted rock is called MAGMA when it is still below the surface. The pressure keeps it stiff, about like toothpaste, even though it's melted. If the magma is squeezed clear to the surface, we say the volcano ERUPTS. Now the magma is not under pressure any more. We call this magma that has come to the surface LAVA. Lava is not under pressure the way magma is, and this changes it. Now it can flow. Some kinds of lava while red hot are almost as runny as water. The lava that makes the volcanoes of Hawaii is this runny kind. The lava that is making a new dome in the Mt. St. Helens crater is rather stiff even when it is red hot, so instead of flowing it pushes up into a dome shape.

Look at the volcano in the picture and at the magma underneath it. You can see that some of the magma is coming out at the top of the big cone, and some of it is coming out through a crack in the side of the big cone and making a little cone. Mt. Shasta in California has a smaller cone on one side made this way. The smaller cone is named Shastina.

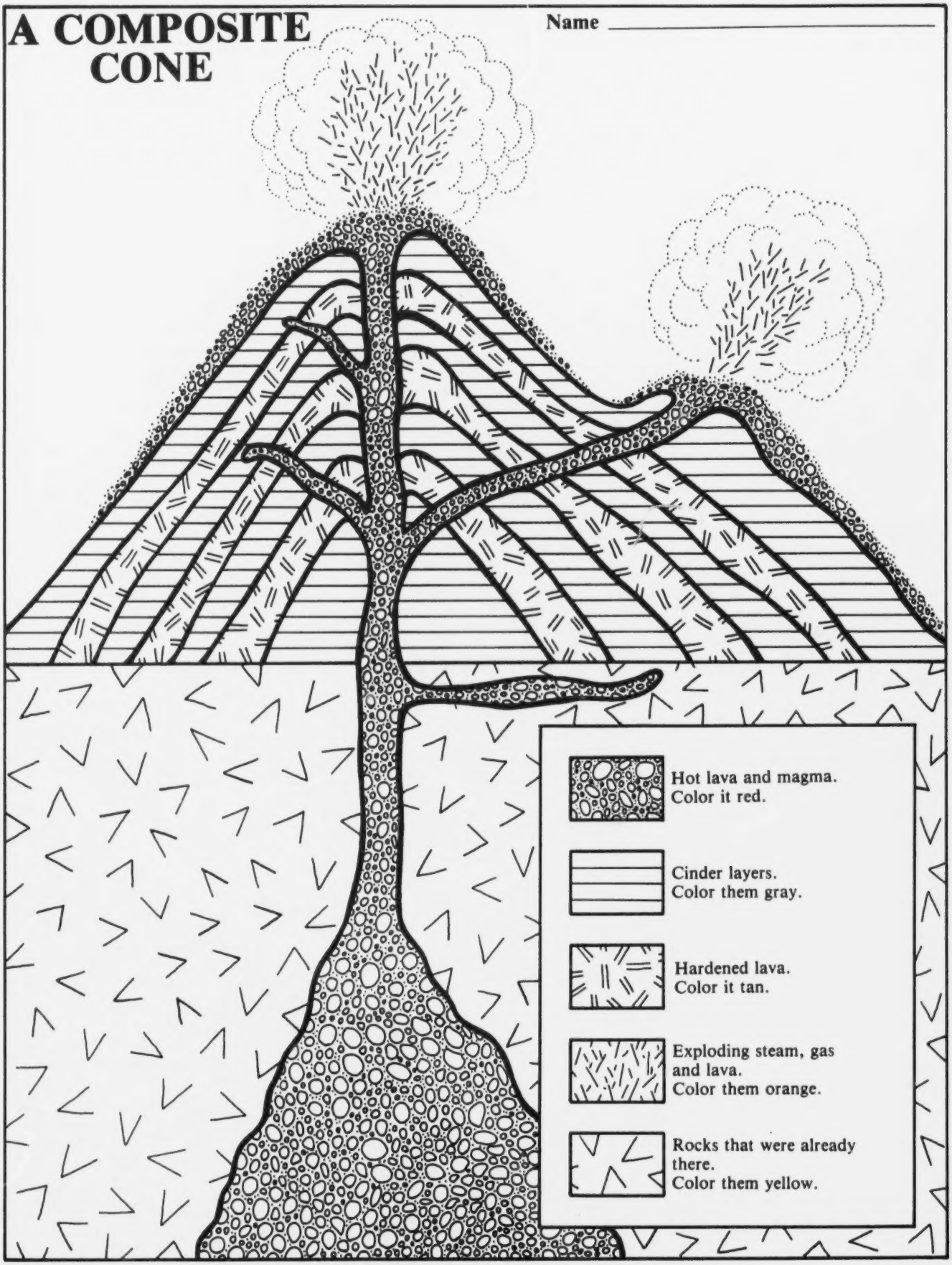
1. Magma is stiffer than lava because
   a. it is hotter.
   b. the rocks above press down on it.
   c. it has stones in it and that makes it thicker and stiffer than lava.

2. If lava flows through a forest,
   a. the trees will becomes petrified.
   b. the trees will burn.
   c. the trees will stop lava.

3. From the story you can tell that
   a. scientists have been reading a lot of books about volcanoes.
   b. scientists have been digging underneath volcanoes.
   c. scientists have been studying volcanoes carefully.

A COMPOSITE CONE

Name _____



LESSON 6

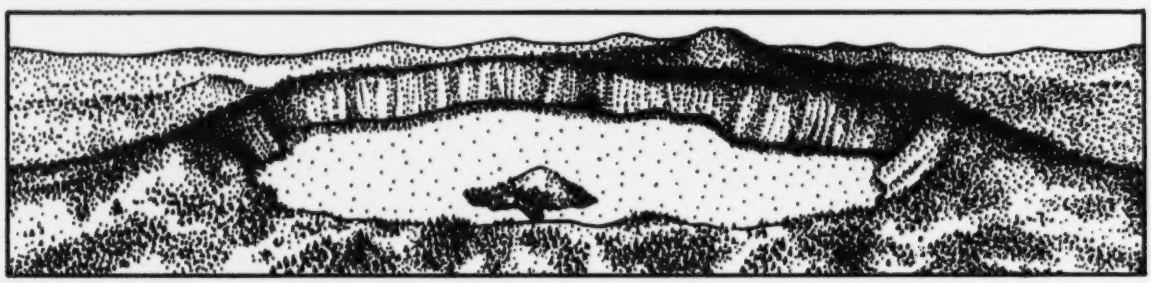
Name _____

CRATER? CALDERA?

Crater Lake in Oregon is 9 kilometers across and 2,500 meters above sea level. About 7,000 years ago it was a volcano 4,000 meters tall. We call it Mt. Mazama. Then it started erupting over and over. It kept blowing gas and magma into the air, spilling lava over the edge of the crater.

Mt. Mazama blew out about 40 cubic kilometers of magma. No more magma pushed up from deep in the earth. This left a big empty space underneath. Finally the space got so big that the top of Mt. Mazama caved in. This left an enormous crater 2,500 meters high and 9 kilometers across where the 4,000-meter mountain had been. Later, three cinder cones erupted in the crater. After a few hundred years, rain, snow, and melted ice filled the crater with water. One of the cinder cones still shows above the water. It is called Wizard Island.

A big crater like this one, where a volcano caved in, is called a CALDERA. The caldera at Crater Lake is easy to see because it is full of water. There are many other calderas in the United States along the West Coast and in Alaska and Hawaii.



WIZARD ISLAND IN CRATER LAKE IS REALLY A CRATER IN A CALDERA.

1. Mt. Mazama is now only 2,500 meters high instead of 4,000 meters as it used to be because
   a. it erupted.
   b. it was worn down by wind, rain, and ice.
   c. the top caved into the space underneath.

2. Once a volcano has erupted
   a. there is less magma under it and it won't erupt again.
   b. the crater will fill with water and cool it off.
   c. it might erupt again.

3. From the story we can tell that
   a. every caldera has a lake in it.
   b. where there is a caldera, there used to be a volcano.
   c. after a volcano caves in, it won't ever erupt again.

Name _____

WATCH MT. MAZAMA BECOME CRATER LAKE

Color the magma and lava red in each of the pictures. The last few pictures show water filling up Crater Lake; color the water blue.

Then cut along the lines and put the pictures in order with number 1 on top of the stack and number 33 on the bottom.

Hold the stack of pictures in one hand and flip through them with the other to see a time-lapse movie of 6,000 years of Crater Lake history.

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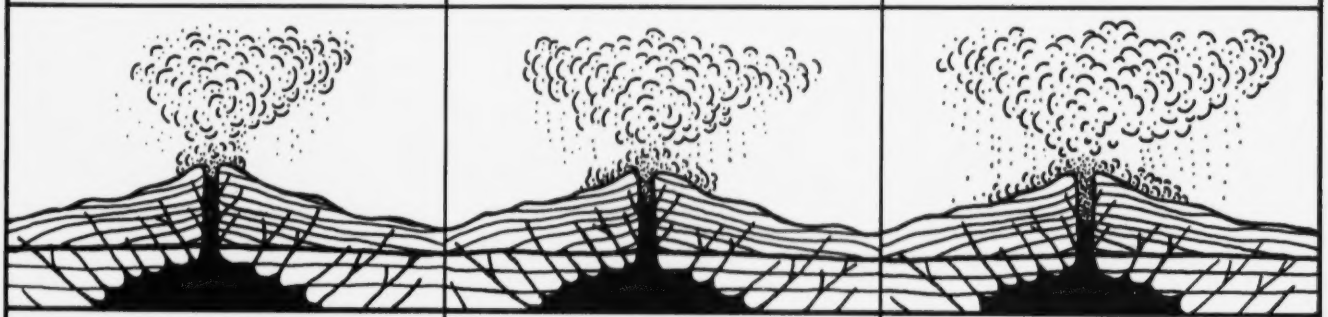

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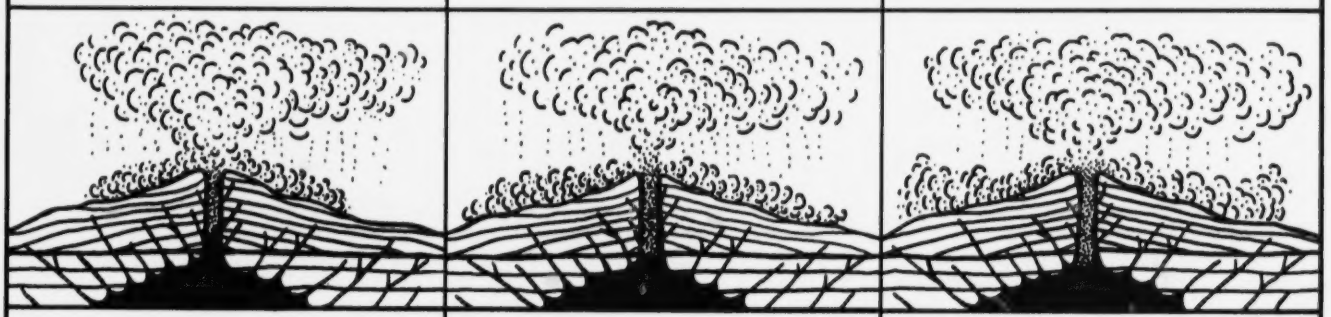

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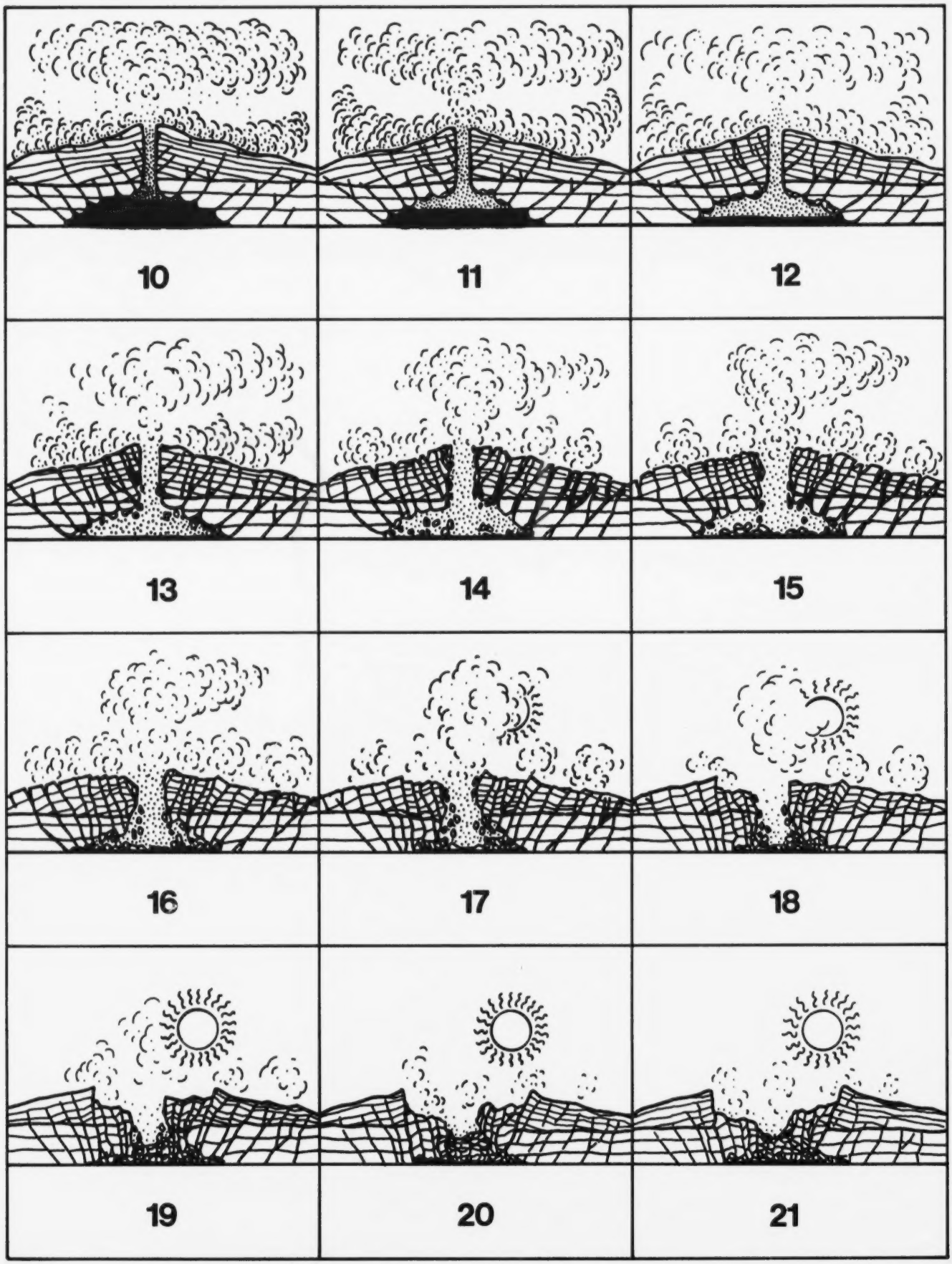
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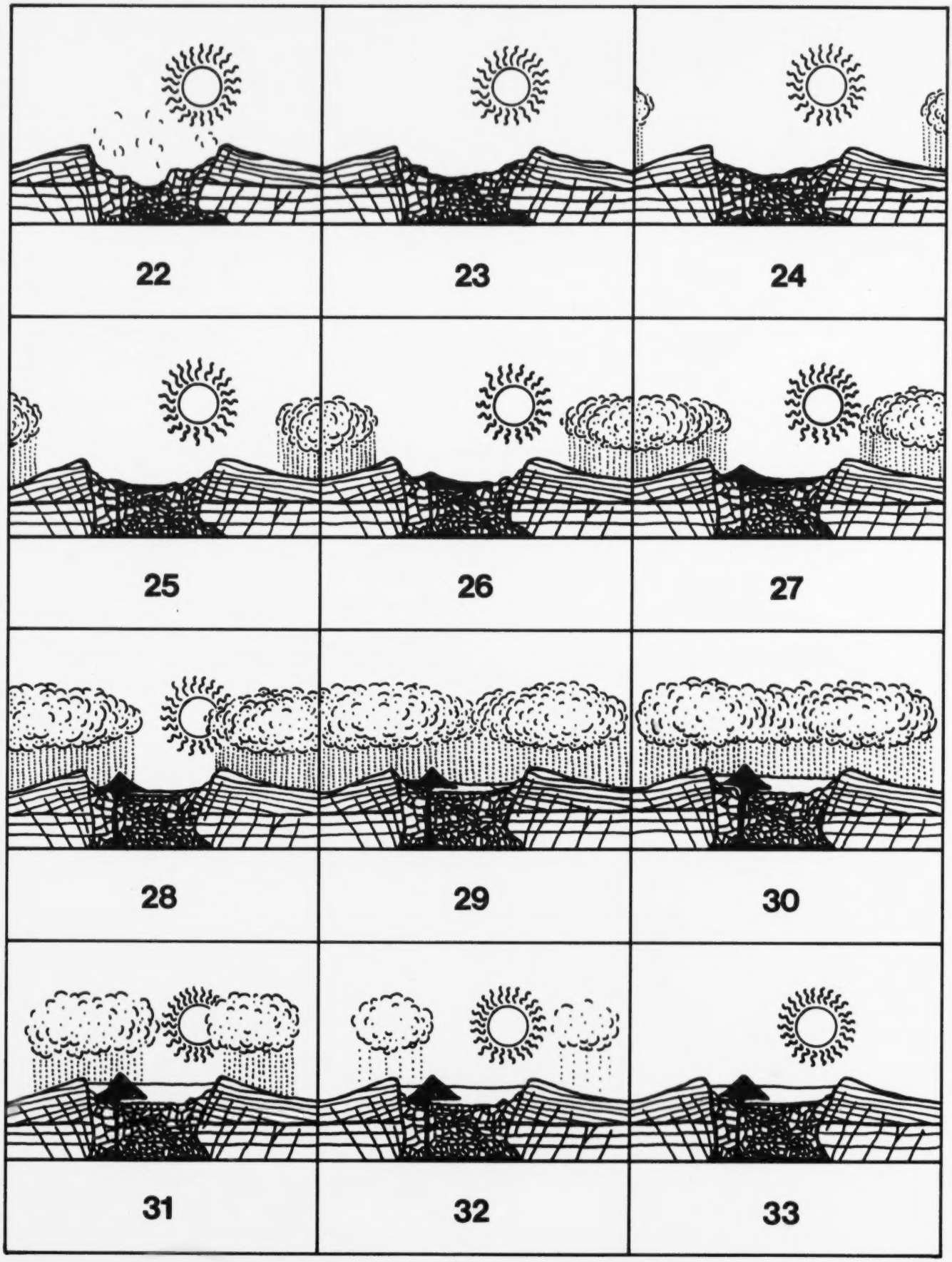
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LESSON 7

Name _____

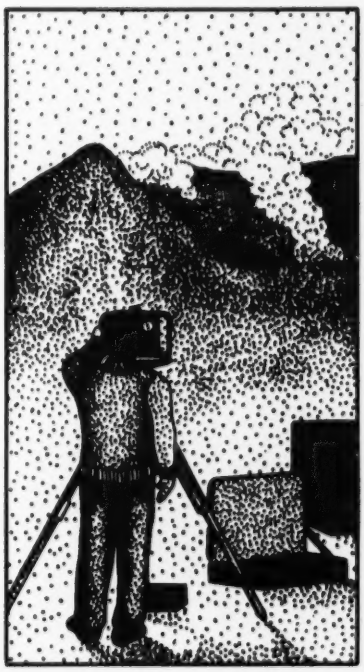
PREDICTING ERUPTIONS

A Mexican farmer felt many small earthquakes for two weeks as he tilled his corn in 1943. Then one day the ground pushed up three meters higher. The ground broke open and smoke and ash started shooting out. The next day there was a cinder cone ten meters high in his cornfield. The cone kept erupting for nine years. The eruptions buried a nearby village in lava and spoiled the farms for many kilometers around by covering them with deep ash. The new volcano, named Paricutin, is now 410 meters high.

Magma moving up from below makes the ground above it shake. This shaking helps people predict that a volcano is going to erupt. The moving magma makes the ground swell, too. Scientists in Hawaii use instruments called TILTMETERS to watch the swelling of the ground. This helps them to predict where the next eruption will happen.

Gases escaping from the magma may seep up through the ground. Sometimes scientists can measure these gases. A sudden change may predict an eruption. Sometimes animals seem to smell the change in gases and this makes them nervous. The Chinese government trains many people to watch for strange animal behavior and report it so that people can move away from dangerous places.

An old, snow-covered volcano may warm up, melt areas of snow, and form new steam vents. This happened at Mt. Baker in Washington state in 1975. It has not exploded yet, but scientists are watching it carefully for the four signs that an eruption is close—many small earthquakes, swelling ground, a change in gases, and new warm spots.



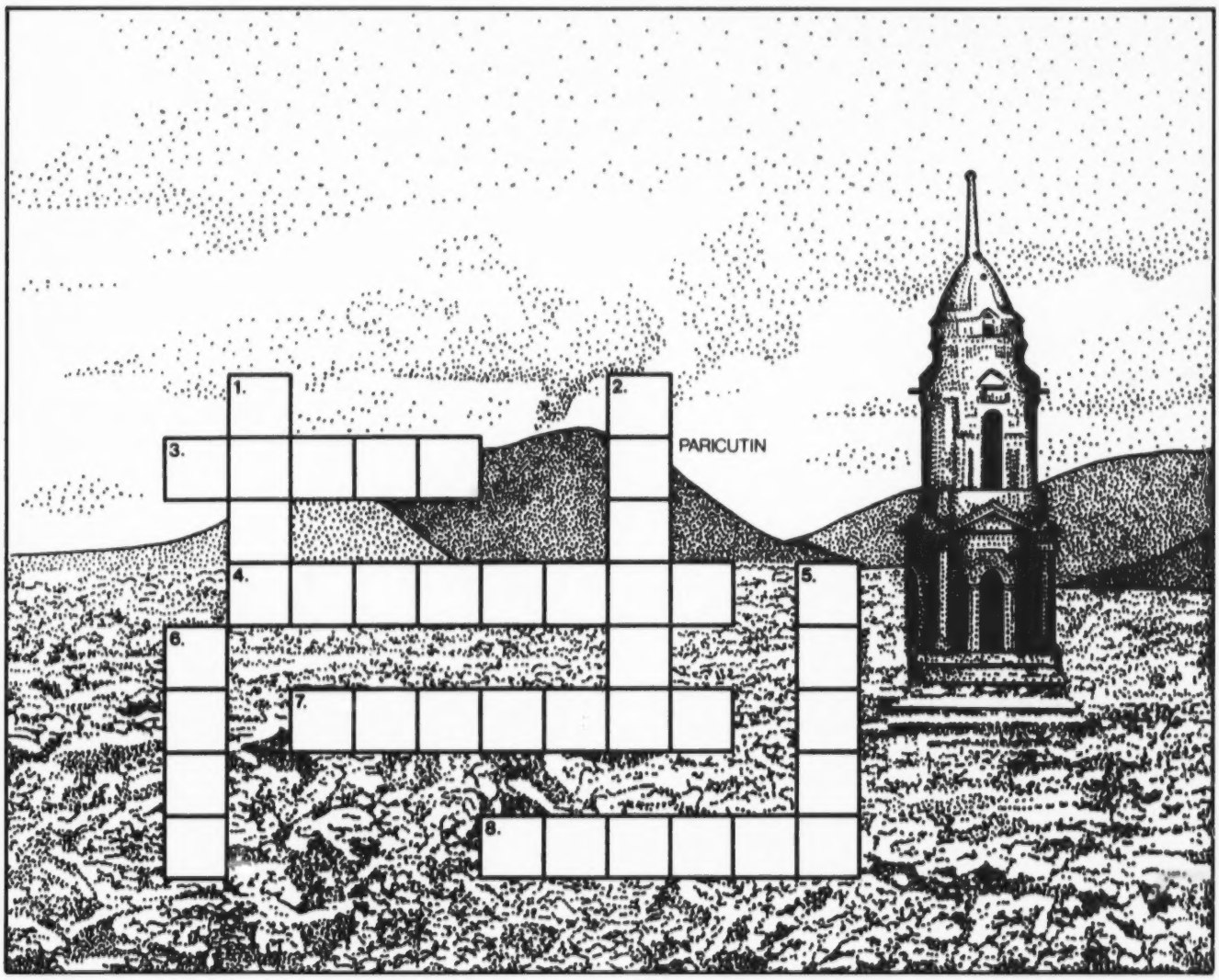
1. Before an eruption there are many small earthquakes because
   a. animals smell escaping gases.
   b. warm ground moves faster than cold ground.
   c. moving magma pushes the ground out of its way.

2. When there are many small earthquakes near a volcano, you can predict that
   a. an eruption is likely.
   b. an eruption is not likely.
   c. the weather will change.

3. From the story you can tell that
   a. moving magma always causes volcanoes to erupt.
   b. volcanoes usually give warning signs before they erupt.
   c. magma comes from the earth's hot core.

Name _____

VOLCANO CROSSWORD PUZZLE



WORD BANK

andesite
basalt
caldera
crater
erupt
lava
magma
vent

ACROSS

3. underground melted rock
4. volcanic rock that can hold a lot of gas
7. a crater more than one mile across
8. volcanic rock that can hold only a little gas

DOWN

1. rock, hard or melted, that came from a volcano
2. bowl-shaped hole in the top of a volcano
5. blow out lava, gas, rock, or ash
6. opening in a volcano where lava, ash, gas, and rocks pour out

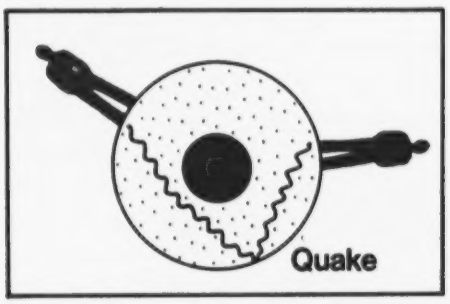
LESSON 8

Name _____

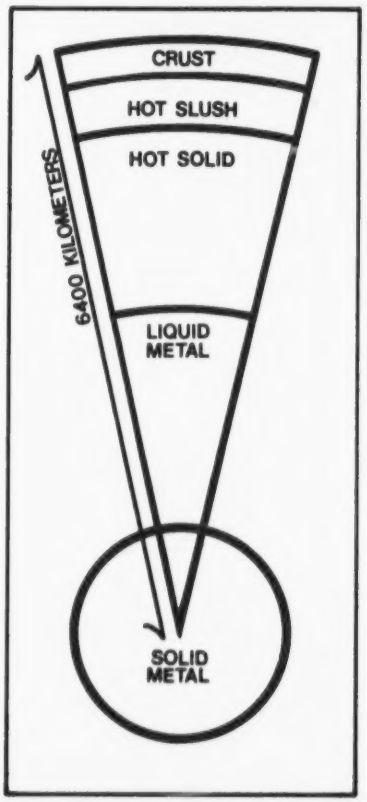
WHAT'S INSIDE THE EARTH?

Have you listened to someone tap two stones together in a swimming pool? It sounds quite different above the water and under the water. Put your ear down on one end of a table and have someone tap the table at the other end. It sounds quite different when your ear touches the table than when you're standing away from it. Sound waves travel better through solid and liquid than they do through the air.

Scientists listen with special instruments to waves traveling under ground and through the earth. Often these waves are made by earthquakes. Waves from the same earthquake travel at different speeds through different kinds of earth. Scientists can compare these speeds and learn what the earth is made of.



Scientists now think that the earth has a solid, very hot core of metal about 2,500 kilometers across. Outside this is a very hot layer of liquid metal about 2,000 kilometers thick. Above this is a 3,000-kilometer layer which is very hot and solid. Between this hot, solid layer and the cool, solid crust is a slushy layer of solid rock mixed with molten rock. The slushy layer and the crust are different thicknesses in different places. They total about 150 kilometers. The solid layer of crust covers the earth and goes under the ocean as well as under the continents.



1. An Indian put his ear to the ground to listen for horses coming. This worked because
   a. sound travels better through the solid ground than through air.
   b. putting his ear to the ground blocked out other sounds.
   c. with his ear to the ground, he could talk with the Earth Spirits.

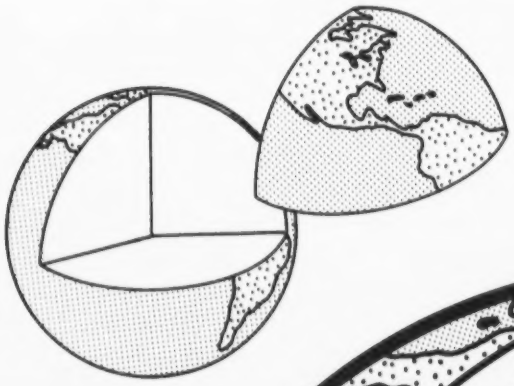
2. If you could dig a hole several kilometers deep, the temperature would
   a. get warmer.
   b. get cooler.
   c. stay the same all the way down.

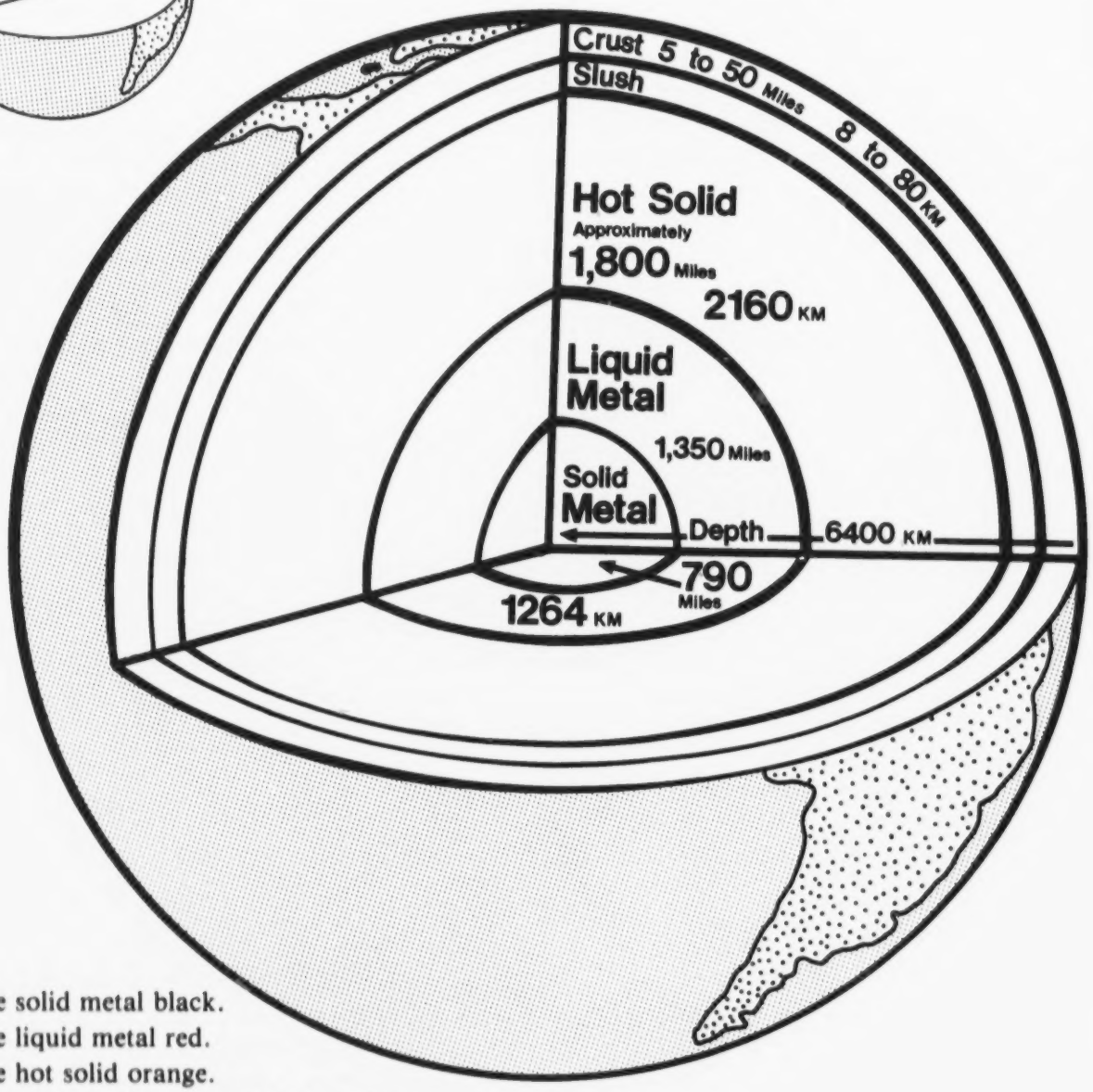
3. From the story you can tell that
   a. earthquakes do a lot of damage.
   b. earthquakes help scientists learn about the inside of the earth.
   c. earthquakes happen at the center of the earth as well as on top.

Name _____

INSIDE THE EARTH

The center of the earth is very hot because of all the pressure on it. The deeper it is, the hotter it gets. Rocks that are 100 kilometers or so deep are melted. Metals like iron, silver, tin, and gold are melted, too. The pressure near the center of the earth is so great that metal which is hot enough to be melted is pressed into a solid in spite of its heat.





Color the solid metal black.
Color the liquid metal red.
Color the hot solid orange.
Color the surface blue where there's water.
Color the slush yellow.
Color the crust brown.
Color the surface green where there's land.

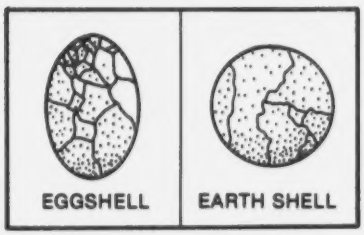
26

LESSON 9

Name _____

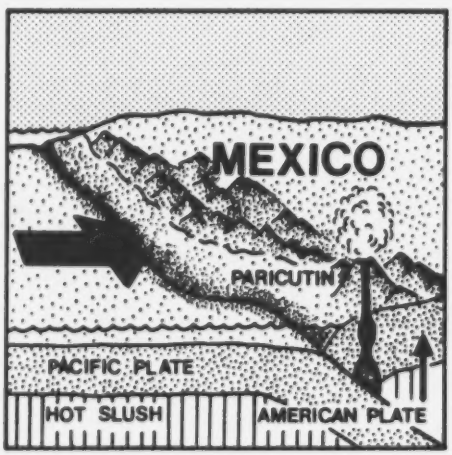
EARTH IS ALL CRACKED UP

When you crack the shell of a hard-boiled egg, you get a lot of separate plates of shell. The crust of the earth is broken into plates, too, but the plates of the earth's crust don't stay put like the plates on a hard-boiled egg. The plates of the earth's crust move very slowly—just a few centimeters a year.



Some of the plates of the earth's curst are growing. Magma from the layer of "slush" under the crust pushes up between the plates. This makes mountains. The floor of the Atlantic Ocean has a ridge of mountains made this way going from the Arctic to the Antarctic.

When a plate of the earth's crust grows at one edge, the other edge gets pushed up against another plate. Something has to give. In many places the growing plate pushes down under the plate next to it, and the edge goes down into the slush of partly melted rock under the crust. Where one plate presses and rubs against the other, some of the rock turns to magma. This magma is lighter than the rock around it, so it slowly moves up. If it gets to the top it will form volcanoes. As it moves up, it pushes other rock out of its way. This makes earthquakes. Many of the world's earthquakes and volcanoes happen where one of the plates in the earth's crust is pushing under another plate.



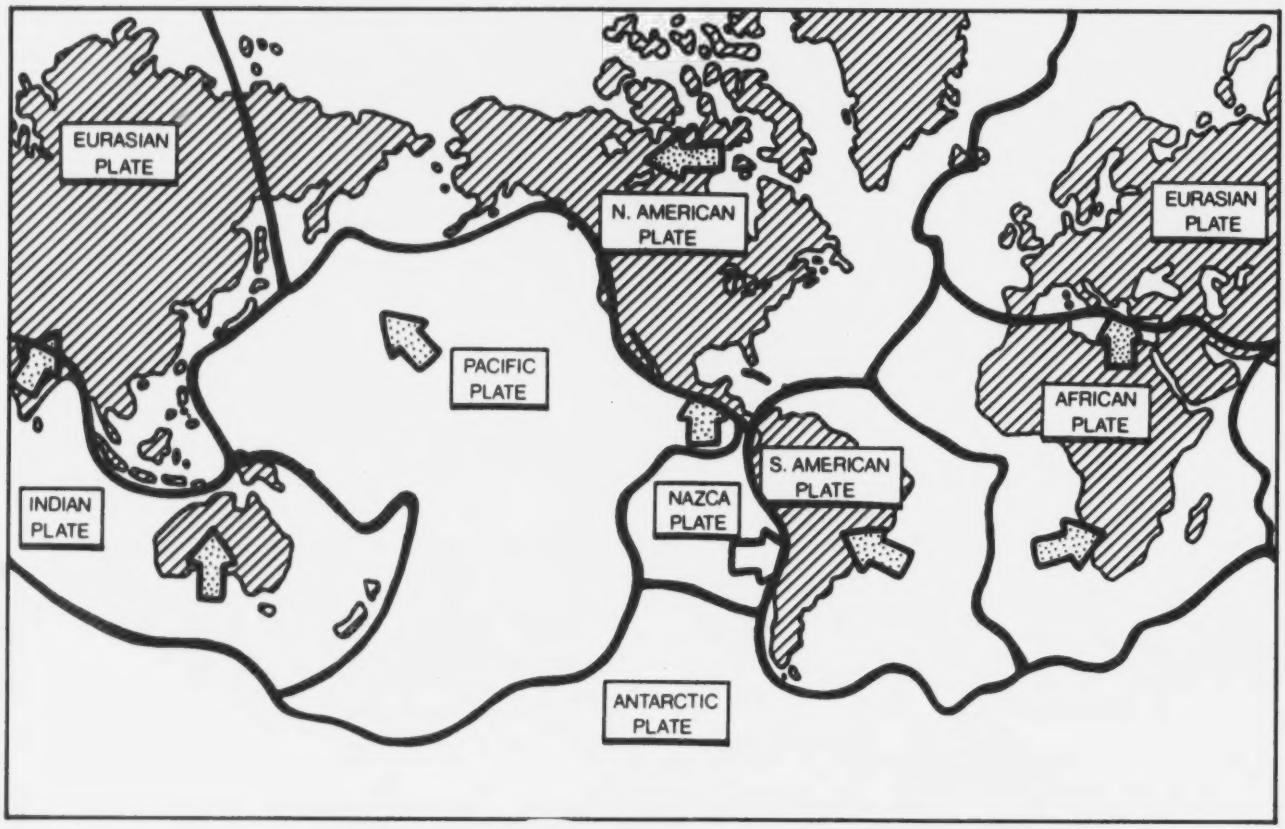
1. Many volcanoes and earthquakes are caused by
   a. thunderbolts.
   b. meteors cracking the earth's shell.
   c. magma pushing up from below.

2. If you live over the place where one plate is pushing down under another, you may
   a. hear the scraping together of the plates.
   b. see volcanoes or feel earthquakes.
   c. be able to dig a hole deep enough to see what's going on.

3. From this story you can tell that
   a. volcanoes and earthquakes are more likely some places than others.
   b. hurricanes and tornadoes don't happen near volcanoes.
   c. the ocean floor is flat and smooth.

Name _____

PLATES OF THE EARTH'S CRUST



Most scientists agree that the earth's crust is made of plates that move slowly. They are not yet sure exactly where all the edges are, nor even just how many plates there are in all. This map shows the biggest plates as we now think of them. In a few years we will know more.

Choose a color for each of the eight big plates. Show in the boxes below what color you plan to use for each. Color lightly so you can read the labels.

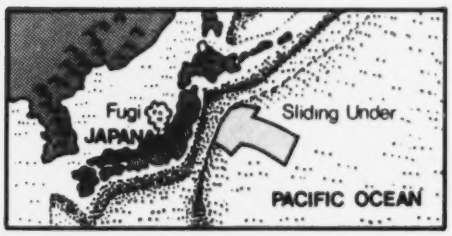
- ☐ African Plate
- ☐ Antarctic Plate
- ☐ Eurasian Plate
- ☐ Indian Plate
- ☐ Nazca Plate
- ☐ North American Plate
- ☐ Pacific Plate
- ☐ South American Plate

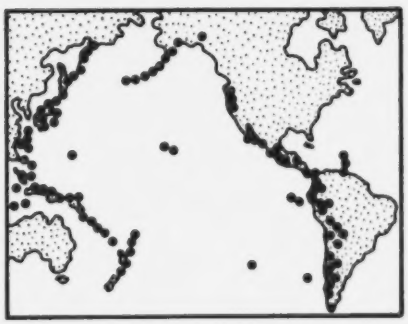
LESSON 10

Name _____

THE RING OF FIRE

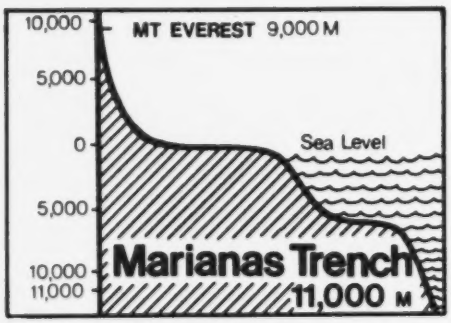
The deepest places in the ocean are called TRENCHES. Trenches are made where one plate in the earth's crust pushes down under another plate. Volcanoes and earthquakes are also made where one plate pushes under another, so trenches, volcanoes, and earthquakes are often near each other.





Most of the deep trenches are around the Pacific Ocean, so many of the world's earthquakes and volcanoes are also around the Pacific Ocean. This area is called the RING OF FIRE because of all the volcanoes and earthquakes there.

The deepest trenches in the world are deeper than the tallest mountains in the world. The top of Mt. Everest, the tallest mountain, is about 9,000 meters above sea level. The bottom of the Marianas Trench, the deepest trench, is about 11,000 meters below sea level. Both Mt. Everest and the Marianas Trench were formed by plates of the earth's crust moving and pushing against each other.



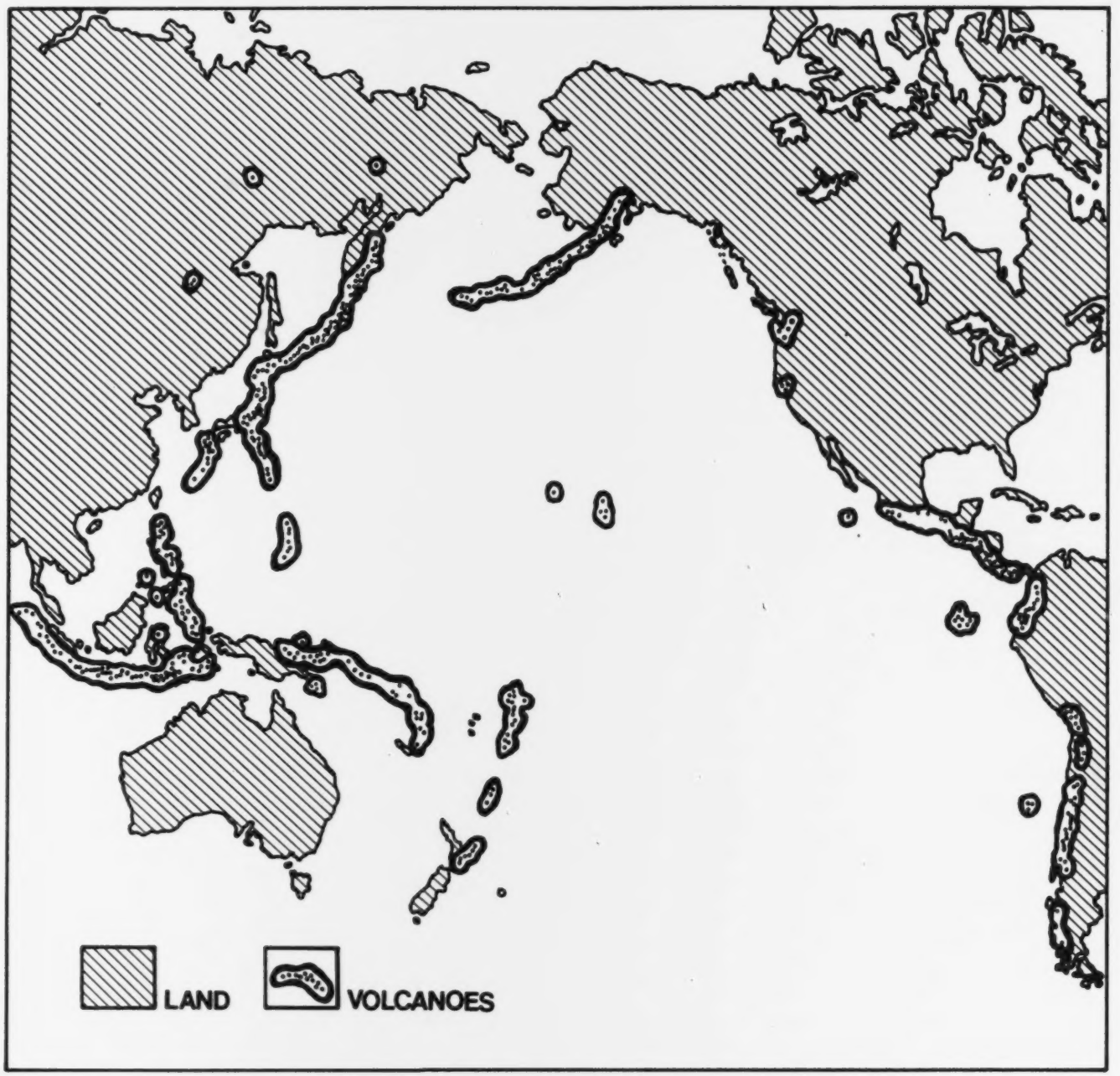
1. Because the plates of the earth's crust move around and press and rub against each other,
   a. trenches in the ocean are 11,000 meters deep.
   b. lakes and rivers are formed.
   c. mountains and trenches are formed.

2. If there is a deep trench in the ocean, you can predict that
   a. the land nearby will have volcanoes or earthquakes.
   b. the mountains nearby will be very tall.
   c. the cities nearby will have very deep harbors.

3. If an area has many volcanoes, that area probably also has
   a. a ring of fire.
   b. many earthquakes.
   c. many hurricanes.

Name _____

RING OF FIRE



First label the Pacific Ocean and the continents around it: North America, South America, Australia, and Asia.

Then color those areas red where there are many earthquakes or volcanoes.

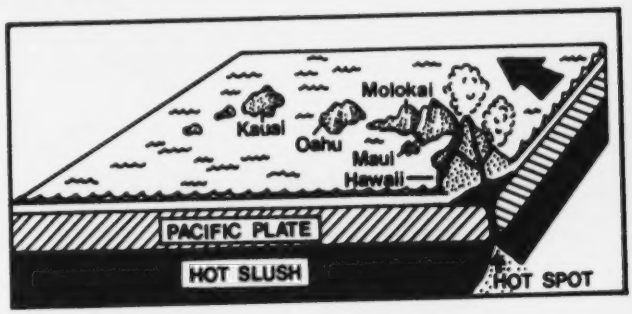
Then color the land green and the ocean blue. Be sure you can still read the labels.

LESSON 11

Name _____

WHAT ABOUT HAWAII?

Hawaii is a string of shield volcanoes in the Pacific Ocean. We expect volcanoes where one plate is pushing underneath another, but Hawaii sits in the middle of the Pacific Plate far from any edge. What are volcanoes doing there?



Some scientists think that there are places under the earth's crust where the slush is hotter than it is elsewhere. These places are called "hot spots." One hot spot causes the geysers and hot springs in Yellowstone Park. Another hot spot formed Hawaii.

The Pacific Plate is moving northwest at about ten centimeters a year. Hawaii is riding along on top of it. Right now the hot spot that made the Hawaiian islands is underneath the Big Island and is making the volcanoes Kilauea and Mauna Loa erupt. About a million years ago, the hot spot made the island of Maui. Then Maui moved away from the hot spot, carried along on the moving Pacific Plate. A million years earlier than that the hot spot made Molokai; a million years before that it made Oahu; and a million years before that it made Kauai. Kauai is five million years old; it is the oldest of the islands. Northwest of Kauai is a string of islands, mostly underwater, all in a row. The farther away they are from Kauai, the older they are. All of them were made by the same hot spot. They all used to be above water, but the waves slowly wore them away.

The Pacific Plate is underneath all of these islands. The plate is made of basalt, like other ocean plates. Melted basalt is the lava that made the Hawaii islands. Melted basalt is almost as runny as water and does not dissolve much gas, so the volcanoes that make the Hawaiian islands are shield volcanoes with gently sloping sides. The lava sometimes runs over farmlands and through villages, but it does not explode like the lava that made Mt. St. Helens and Mt. Mazama.

1. The underwater islands northwest of Kauai disappeared because
   a. they sank.
   b. they blew up.
   c. waves wore them down.

2. A million years from now the hot spot under Hawaii will probably
   a. still be making Mauna Loa and Kilauea erupt.
   b. be building a new island.
   c. move to a different part of the ocean.

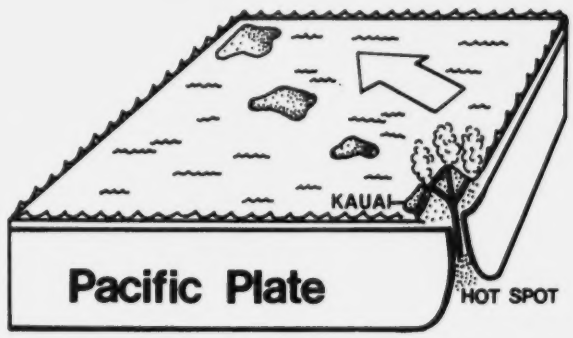
3. From the story you can tell that
   a. hot spots always form islands in the middle of the ocean.
   b. you can't have an island without a hot spot.
   c. hot spots can make volcanoes.

Name _____

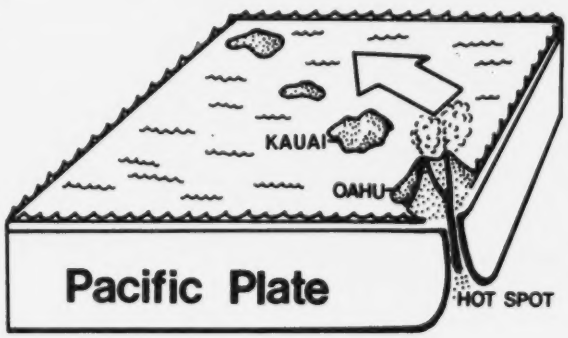
HAWAII: TRAVELING ISLANDS

Every million years or so, many scientists believe, the hot spot under Hawaii gets active and makes another island. Then it cools. The new island moves along with the plate beneath it and the next time the hot spot gets active it makes another island.

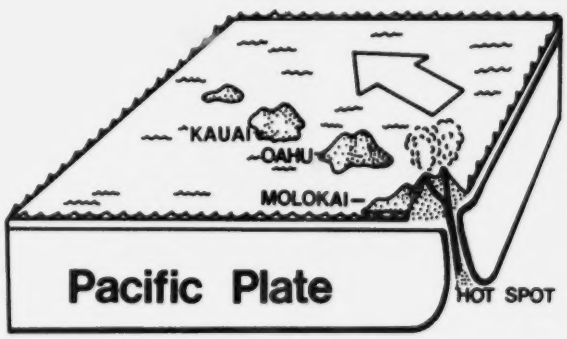
Color the Pacific Plate light gray and the ocean light blue. Be sure you can still read the words. Color the hot spot and the island over it red; color the next island orange; the next yellow; the next green; and the last purple. See Hawaii grow.



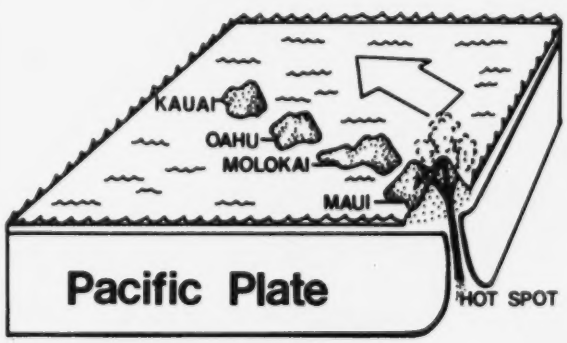
4 Million Years Ago



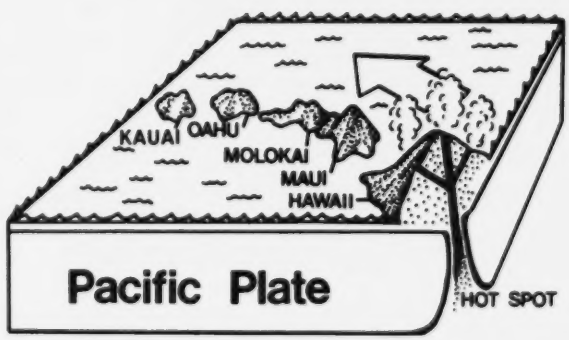
3 Million Years Ago



2 Million Years Ago



1 Million Years Ago

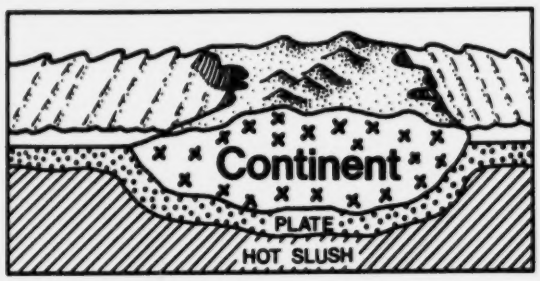


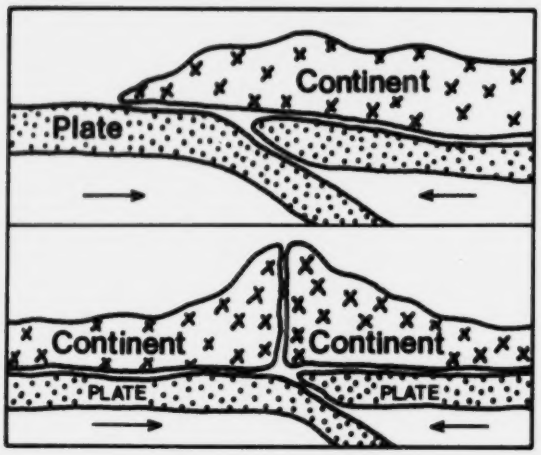
Today

Name _____

PANGAEA: SUPER CONTINENT

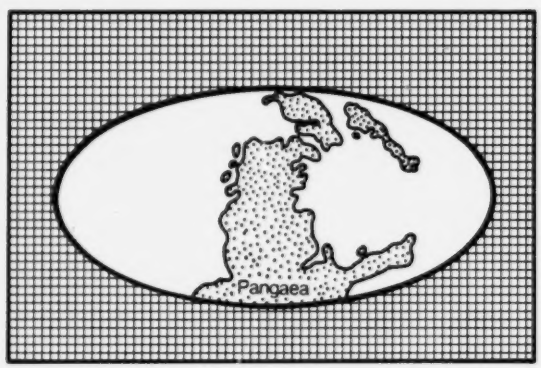
The plates of the earth's crust are made of basalt, which is a very heavy kind of rock. The continents are made of lighter kinds of rock called granite and andesite. When the plates move around, the continents are carried along on top like loads on rafts.





When plates push into one another and one slides under the other, the continents on top don't get pushed under because they are lighter and stay on top. They can be pushed onto another plate, or they can bump into other pieces of continent and crumple up to form mountains. The Alps and the Himalayas were made this way. The rocks on continents are older than the rocks on the floor of the ocean because they never get pushed back under the crust and melted as the plates do.

Two hundred forty million years ago the continents were all bunched together in one super continent. Scientists have named it PANGAEA. It was sitting on plates which began moving apart. This tore the big continent of Pangaea up into the smaller continents we have today. The continents are still moving. The Americas are getting farther away from Europe and closer to Asia at the rate of several centimeters a year. This movement is called CONTINENTAL DRIFT.



1. The continents are made of lighter rocks than the plates, so
   a. plates never get pushed under the crust.
   b. continents never get pushed under the crust.
   c. Pangaea broke up into smaller continents.

2. When the Americas bump into Asia in a few hundred million years
   a. the collision will cause tidal waves.
   b. the collision will kill a lot of people and animals.
   c. the collision will cause new mountains to form.

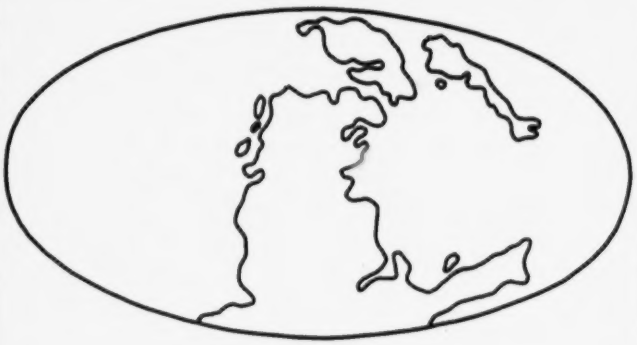
3. From the story we can tell that
   a. continents keep changing, but they never disappear.
   b. we can learn a lot by studying the rocks on the sea floor.
   c. the Himalayas are made of basalt.

Name _____

WATCH THE BREAKUP OF PANGAEA

Color the ocean light blue in all the pictures. Color Pangaea tan. Starting with the third picture, where the words show today's continents, color North and South America light green; Australia tan; India yellow; Africa orange; Europe and Asia violet; and leave Antarctica and Greenland white. Be sure you color lightly enough so that the words show through.

Then cut and stack the pictures as you did for Mt. Mazama (pages 12-14), and flip through them to see a time-lapse movie of 240 million years of continental drift.



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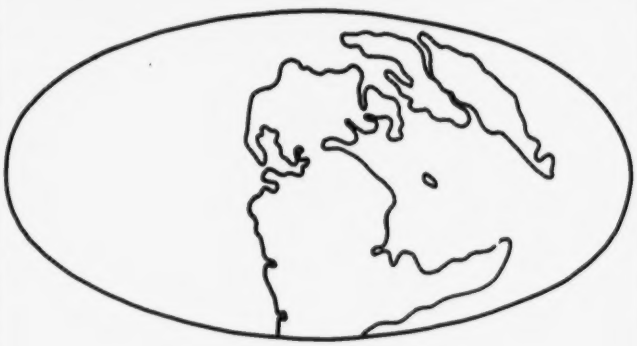

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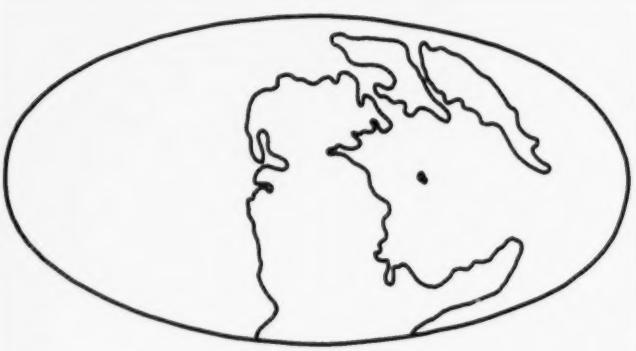

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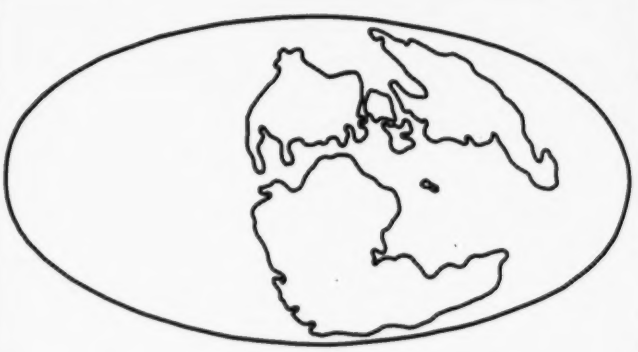

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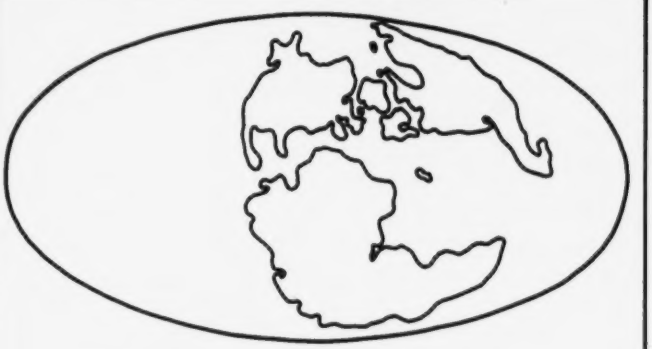

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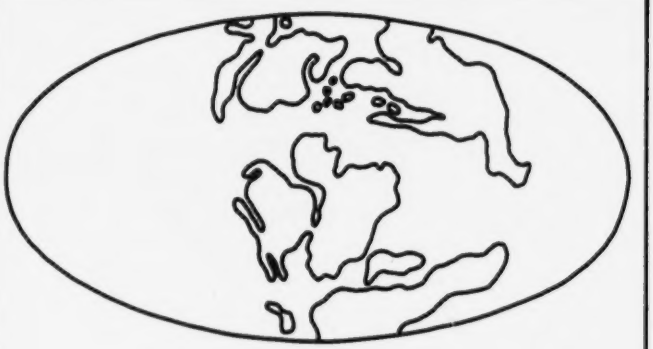

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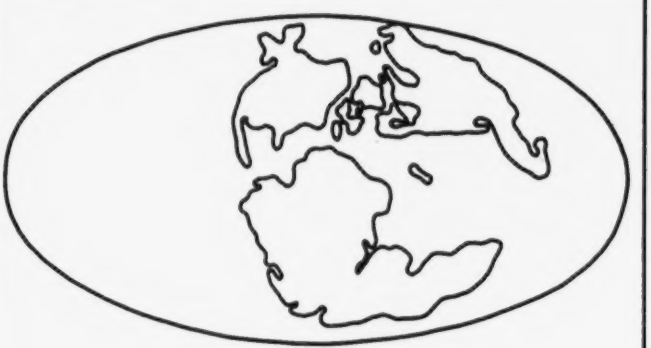

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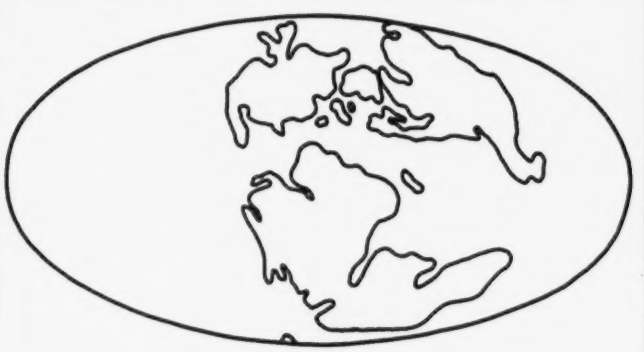

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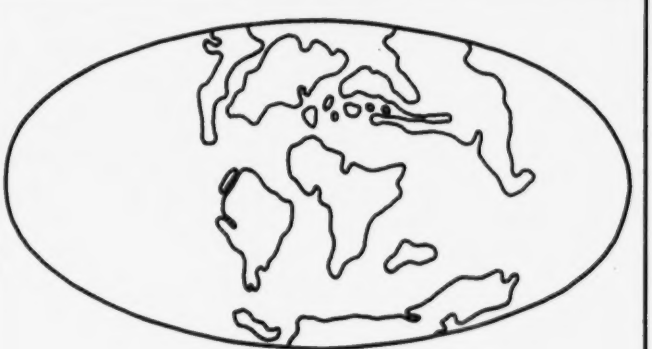

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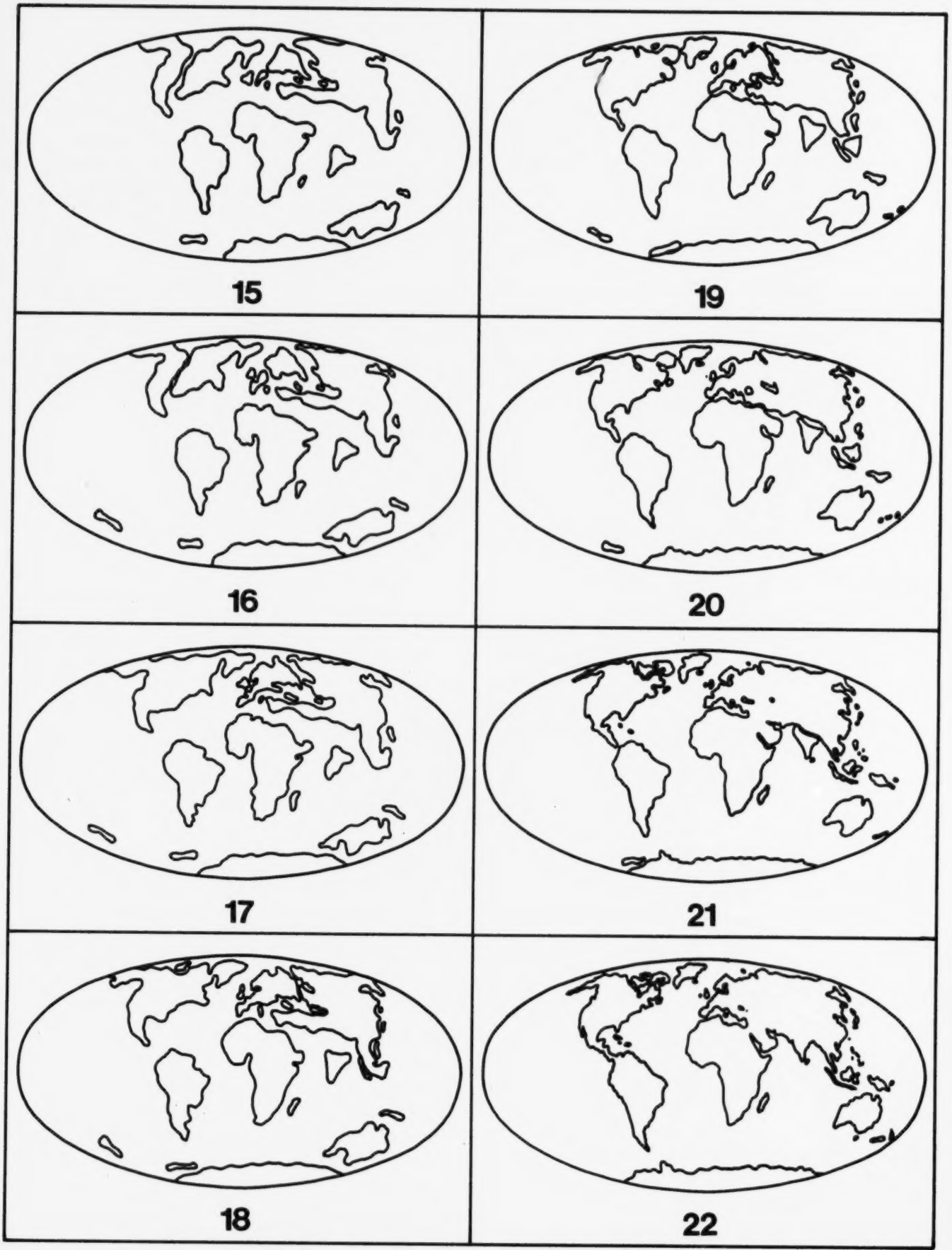
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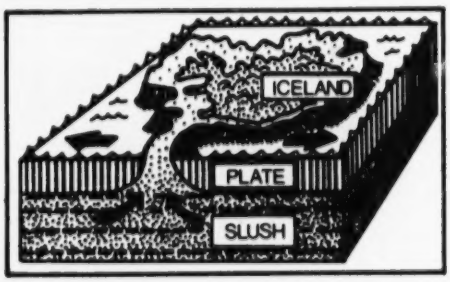
LESSON 13

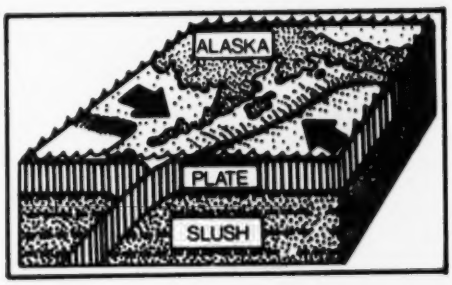
Name _____

PLATE EDGES

Underneath the oceans and the continents, the earth is covered with plates of rock about 60 kilometers thick. Scientists call them TECTONIC PLATES. "Tect" means construction, so tectonic plates are plates that construct the earth's shell. The plates move about and jostle each other in three ways.

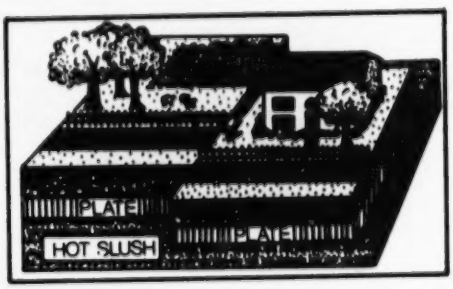
First, plates can pull away from each other. When this happens, melted rock from the hot slush underneath the plates pushes up between them and makes volcanic mountain ridges. Sometimes the tops of the ridges come above the ocean and make land. Iceland was made in this way.





Second, plates can push toward each other. When this happens, one plate bends down under the other, making a deep trench. This causes volcanoes and earthquakes above. The edge of the plate underneath turns back into hot slush after a few million years. Only plates which are made of heavy basalt do this. The lighter continents stay on top.

Third, plates can slide past each other sideways. Scientists call places like these FAULTS. The plates are pushed so tightly together that they can't slide smoothly. They move in jerks, like rusty machinery. The jerks in the plates make earthquakes above. The plates keep moving even when the edges seem stuck, so the longer it is between jerks the bigger the jerk (earthquake) will be.



1. Hot slush pushes between tectonic plates and makes ridges where
   a. the plates are pushing together.
   b. the plates are pulling apart.
   c. the plates are sliding past each other sideways.

2. If you live over a place where plates are sliding sideways past each other, you can expect
   a. volcanoes.
   b. earthquakes.
   c. ridges of hot slush.

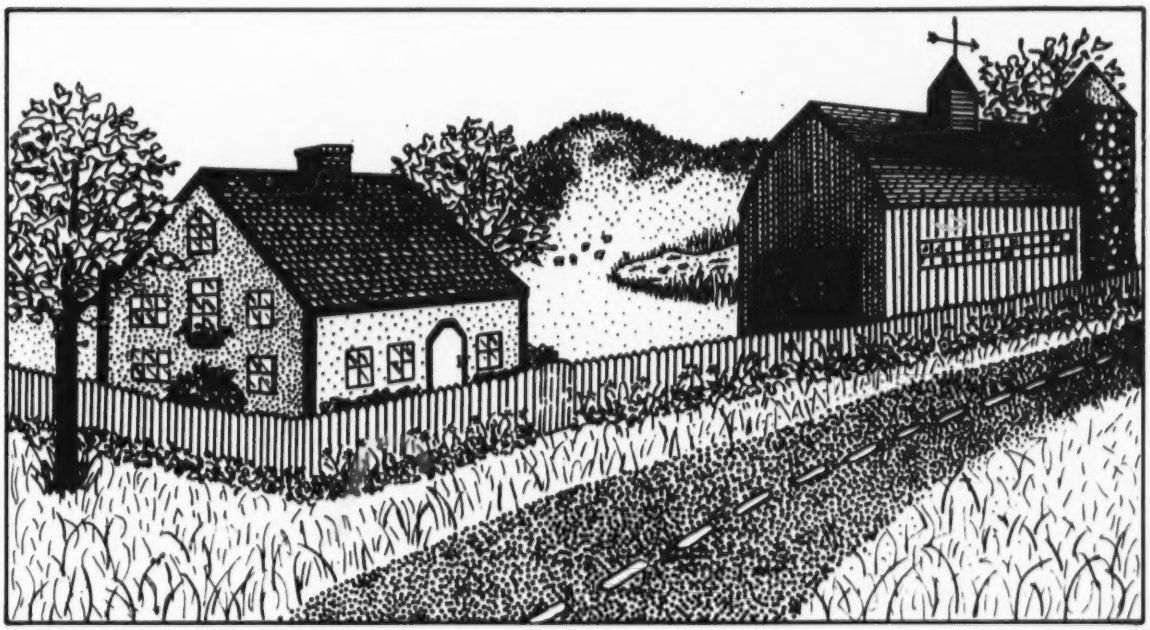
3. If there are very few earthquakes where you live and no volcanoes at all, you are probably
   a. near the middle of a plate.
   b. near the edge of a plate.
   c. over a fault.

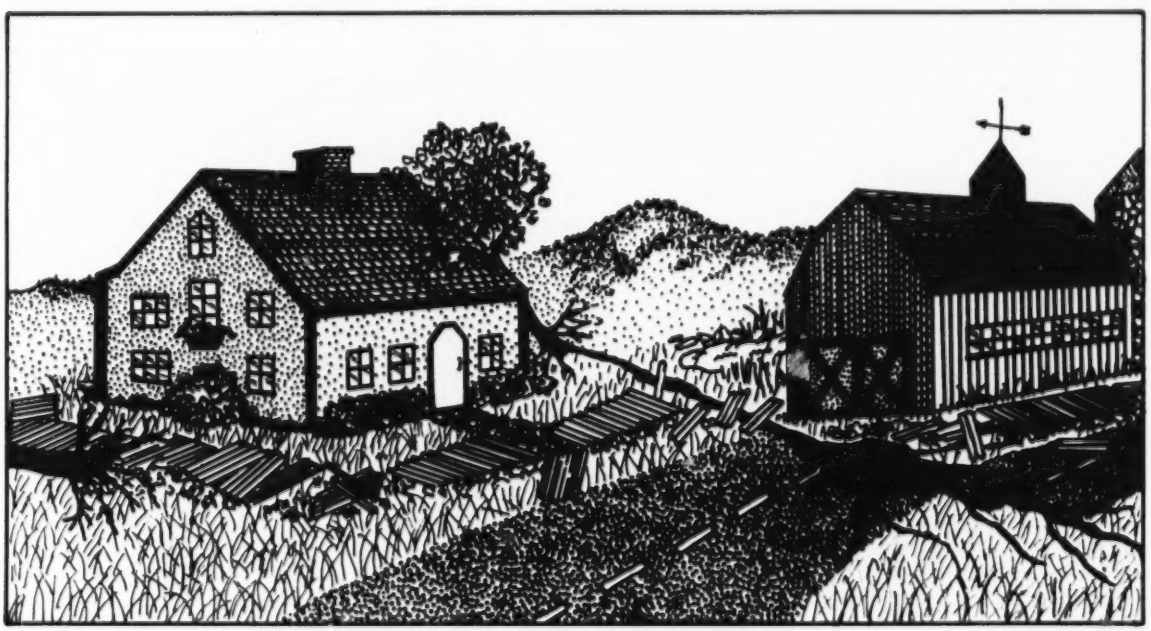
37

Name _____

EARTHQUAKES REARRANGE THE SCENERY

The pictures below show how the land above can change when plates move past each other sideways. Color them alike.



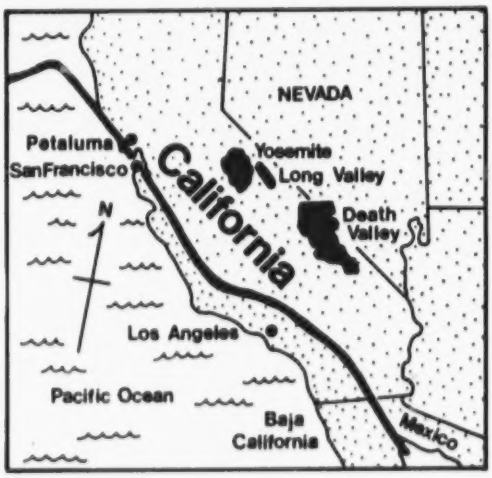


LESSON 14

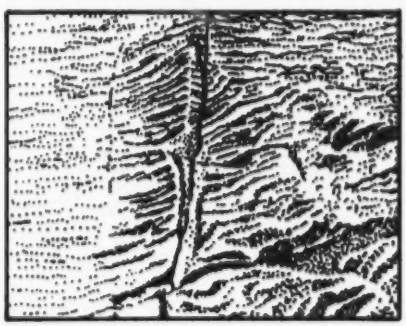
Name _____

WHAT ABOUT CALIFORNIA?

California has two kinds of earthquakes. One kind is caused by magma rising through the ground. Magma is rising under Long Valley east of Yosemite. Long Valley is an old caldera that used to be a volcano. The magma is making earthquakes as it rises. People nearby have built a second road so they can get away quickly if scientists tell them an eruption will happen soon.



The other kind of earthquake is caused by tectonic plates moving sideways against each other. California sits on two tectonic plates. One of them is the North American Plate, which carries most of the rest of North America on it. The other is the Pacific Plate, which is slowly moving northwest and carrying some of California and the part of Mexico called Baja California with it. In a hundred million years that part of the continent will be an island just south of Alaska.



The line where the plates meet is called the SAN ANDREAS FAULT. Look at the map above. The fault goes through the Gulf of California, makes a line through the hills near the coast, and turns west near Petaluma. Many cities are on the San Andreas Fault. California has strict laws about making schools and public buildings earthquake-safe. This will prevent many injuries when the tectonic plates under the San Andreas Fault move again.

1. California has more earthquakes than most states because
   a. there are so many more people there all moving around.
   b. there are so many mountains there.
   c. it is on two plates moving different ways.

2. There are likely to be more earthquakes near Petaluma than in
   a. Death Valley.
   b. San Francisco.
   c. Los Angeles.

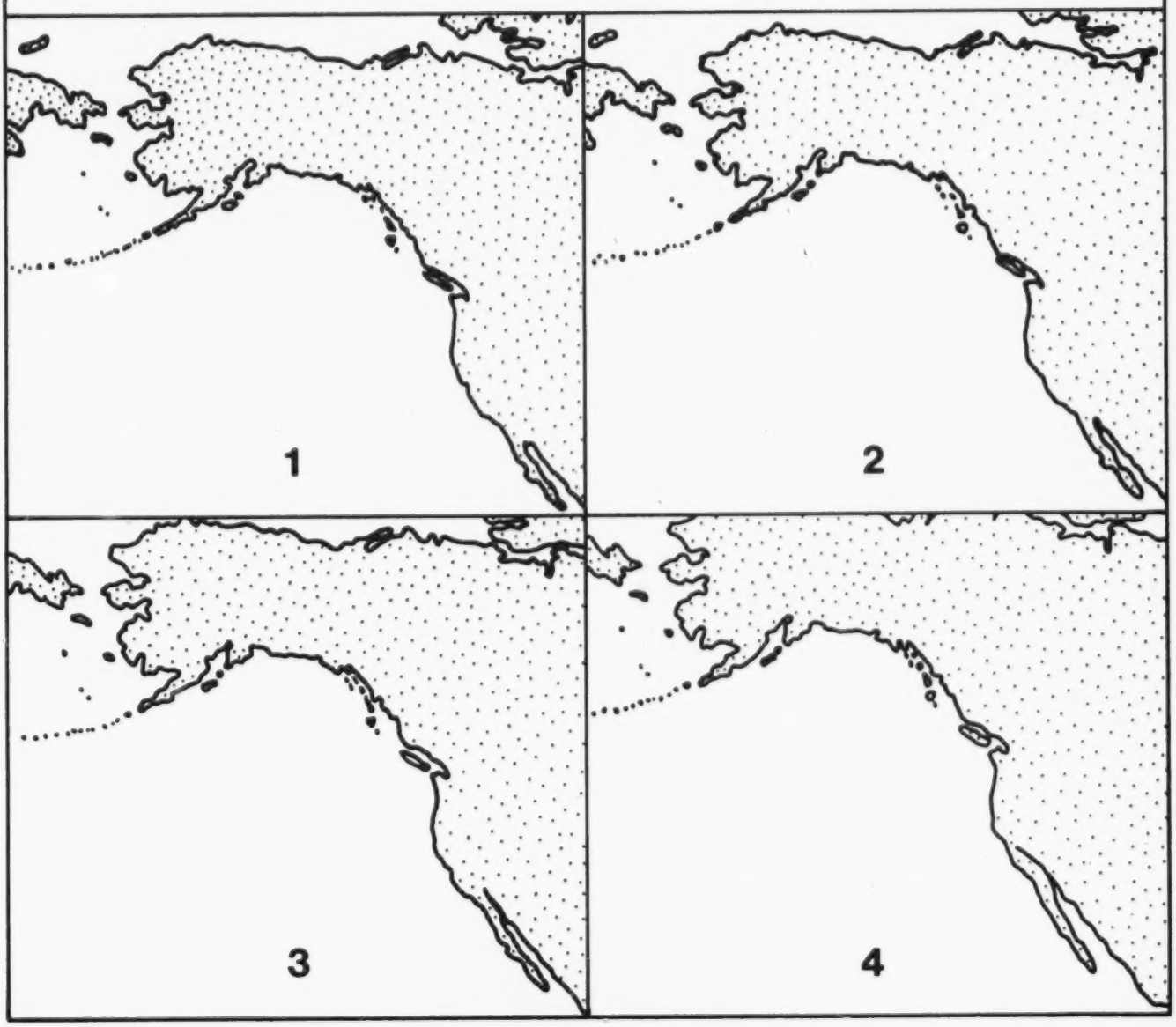
3. You can tell from the story that
   a. California rock is very old and brittle.
   b. people like earthquakes, since so many people live in California.
   c. there is more than one reason for earthquakes.

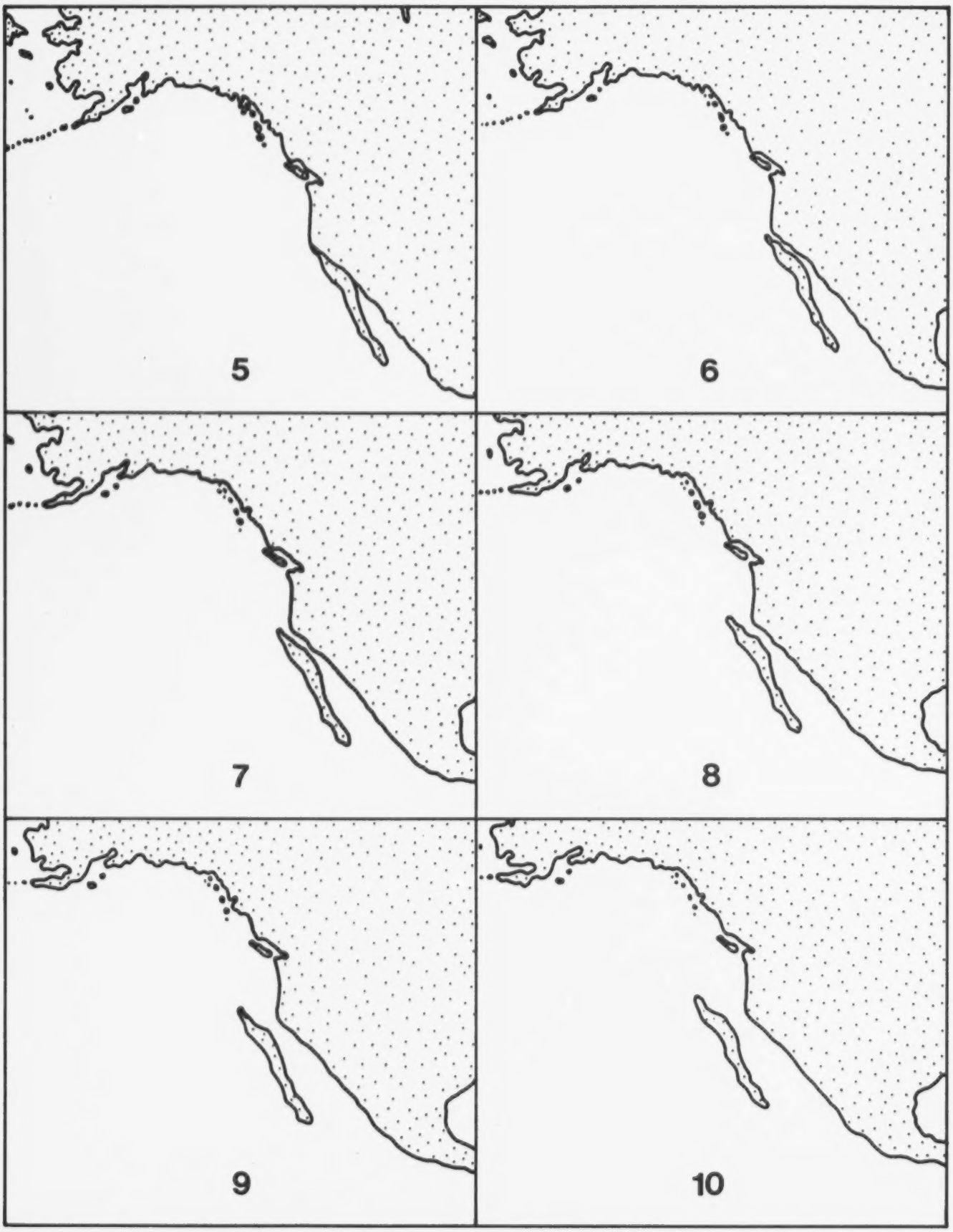
Name _____

SOUTHWEST CALIFORNIA ON THE MOVE

Color the water light blue and the land brown in each of these pictures. Then cut along the lines and assemble them into a flip book, with number 1 on top.

Flip the pages to see a time-lapse movie of 50 million years of California's future.

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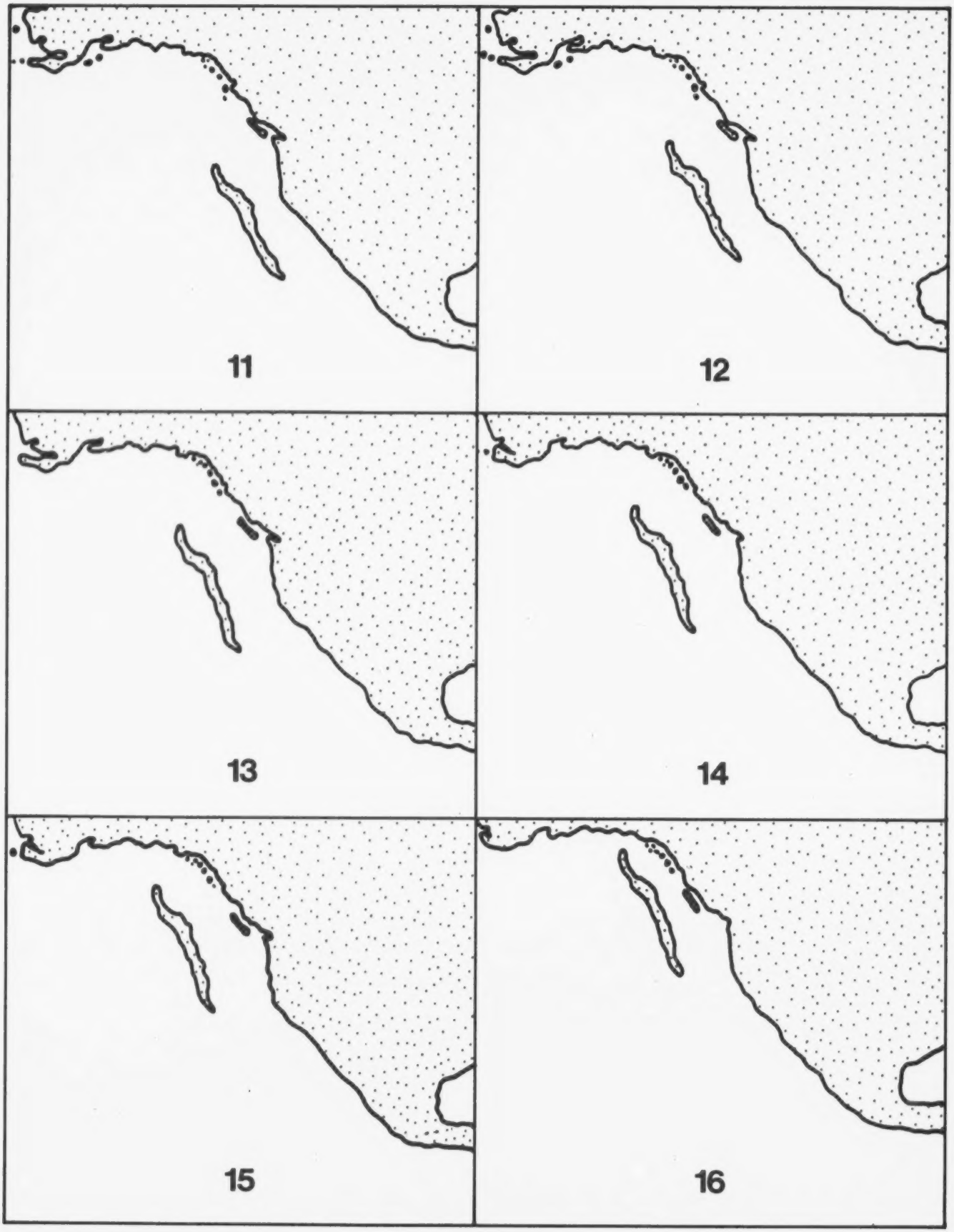
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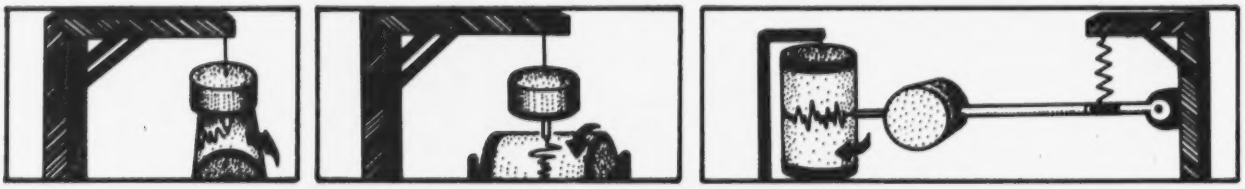
LESSON 15

Name _____

HOW BIG WAS THAT EARTHQUAKE?

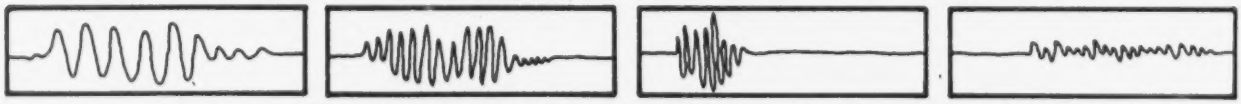
SEISMOS is the Greek word for earthquake. So a SEISMOLOGIST is a person who studies earthquakes, and a SEISMOGRAPH is an instrument that writes the measurement of earthquakes, and a SEISMOGRAM is the trace the pen of the seismograph makes on paper.

Put rocks in a bucket to make it heavy. Tie a rope to the handle and lift it. When the bucket stops swinging, jerk the top of the rope two times from side to side. The bucket will stay almost still because it is so heavy.



A seismograph is like three heavy buckets with pens on them, with paper moving slowly for the pens to write on. When there's no earthquake, the pens make almost straight lines. When the ground shakes, the paper shakes with it but the pens stay still, so they draw wavy lines on the paper. One pen shows how far the paper moved east—west. One pen shows north—south. One pen shows up—down.

In an earthquake, the seismograph trace shows three things. First, it shows how far the ground moves. Second, it shows how fast it moves. Third, it shows how long the shaking lasts. In a really big quake, the ground shakes far, fast, and for a long time.



WHICH SEISMOGRAM SHOWS THE BIGGEST EARTHQUAKE?

1. In an earthquake, the pen makes a wavy line on the paper because
   a. the pen moves back and forth when the ground shakes.
   b. the paper moves back and forth when the ground shakes.
   c. the pen and the paper both move back and forth when the ground shakes.

2. A big earthquake will probably do the most damage if it happens
   a. in a desert.
   b. near the South Pole.
   c. near a city.

3. Earthquakes can make the ground move
   a. from side to side only.
   b. up and down only.
   c. from side to side and also up and down.

Name _____

THE HUMAN SEISMOGRAPH

You will need a partner to do The Human Seismograph activity. The two of you will work together at a desk or table with a toy car, a piece of blank paper at least as big as this one, a ruler, and a pencil.

First draw a stripe to show the seismograph paper. Make it 10 centimeters wide and draw one edge of it in the middle of the paper, as in the picture. Put the toy car on the paper, too.

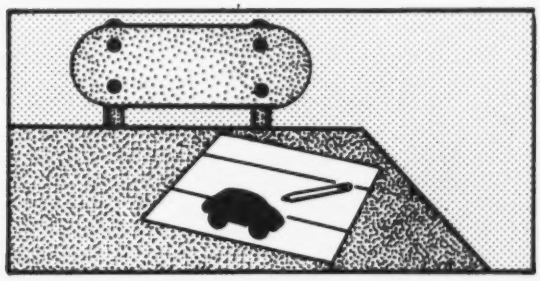
One of you will be the seismograph and hold the pencil on the paper just hard enough to make a mark but not so hard that the paper can't move underneath. Hold the pencil as still as you can.

The other person will move the paper very slowly from left to right under the pencil so that it draws a straight line exactly down the center of the stripe. This shows what a seismogram looks like with no earthquake. Of course, the toy car rides smoothly on the paper.

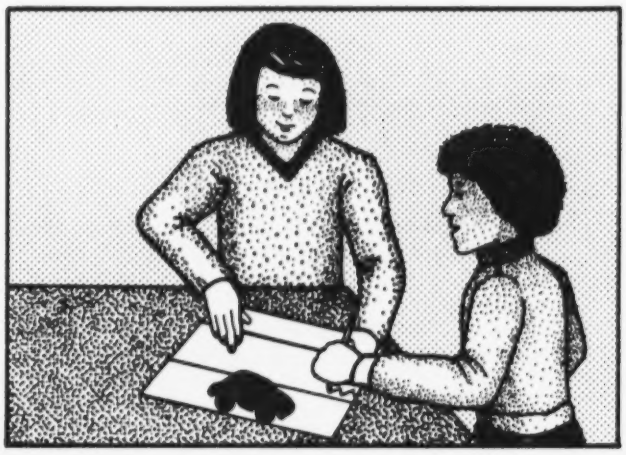
Now pretend that there is a small earthquake. Pull the paper slowly under the pencil again, but this time move it back and forth a little, still keeping the line close to the center. The car may move a little, but try not to make it move much.

Now pretend there is a big earthquake. Move the paper slowly from left to right again, but this time jerk it back and forth so that the pencil makes big zigzags on the stripe. What happened to the car in the big earthquake?

See if you can create an earthquake with a lot of ground motion, but slow enough so that the car doesn't move much.



Your paper should look like this when you start.



Write your partner's name here. _____

Write one thing you learned about earthquakes by doing The Human Seismograph activity.

_____

_____

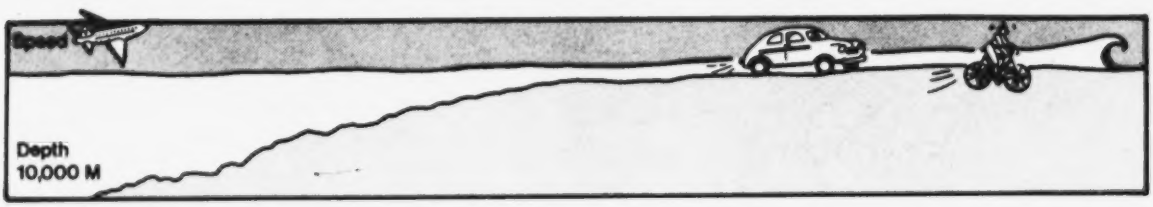
Name _____

TSUNAMI—THE GREAT WAVES

Big earthquakes under the ocean don't shake down buildings, but they can be just as dangerous as big earthquakes under the land. They can kill people and destroy cities thousands of miles away by making huge waves. These waves don't look very big in the middle of the ocean, but as they come near the shallow water near shore they pile up and make breakers just as ordinary surf does, only much bigger. Sometimes the breakers are as high as twelve story buildings.

These great waves are called tsunami (soo NAH me), a Japanese word meaning "storm wave." Many of the world's under-ocean earthquakes take place in the Ring of Fire around the Pacific Ocean, so the Japanese have lost many lives and many cities because of tsunami.

Tsunami can travel very fast. The deeper the water, the faster they travel. Where the ocean is 10,000 meters deep, tsunami travel about as fast as a jet plane. Where the ocean is only 25 meters deep, they travel about as fast as a racing bicyclist.



Seismologists at the Honolulu Observatory use charts showing how deep the ocean is in different places. Their instruments can tell them when and where a big earthquake happens under water. Then they can figure out when the tsunami will arrive at different places and send warnings by radio. People near the earthquake may have only a few minutes to get out of the way; people on the other side of the ocean my have almost a day. This Tsunami Warning System was set up about forty years ago. Before that time, many people were killed by each tsunami; since then, very few.

1. Tsunami used to kill many people. Now they kill very few. This is because
   a. people are more careful than they used to be.
   b. tsunami are smaller than they used to be.
   c. the Tsunami Warning System tells when tsunami will come.

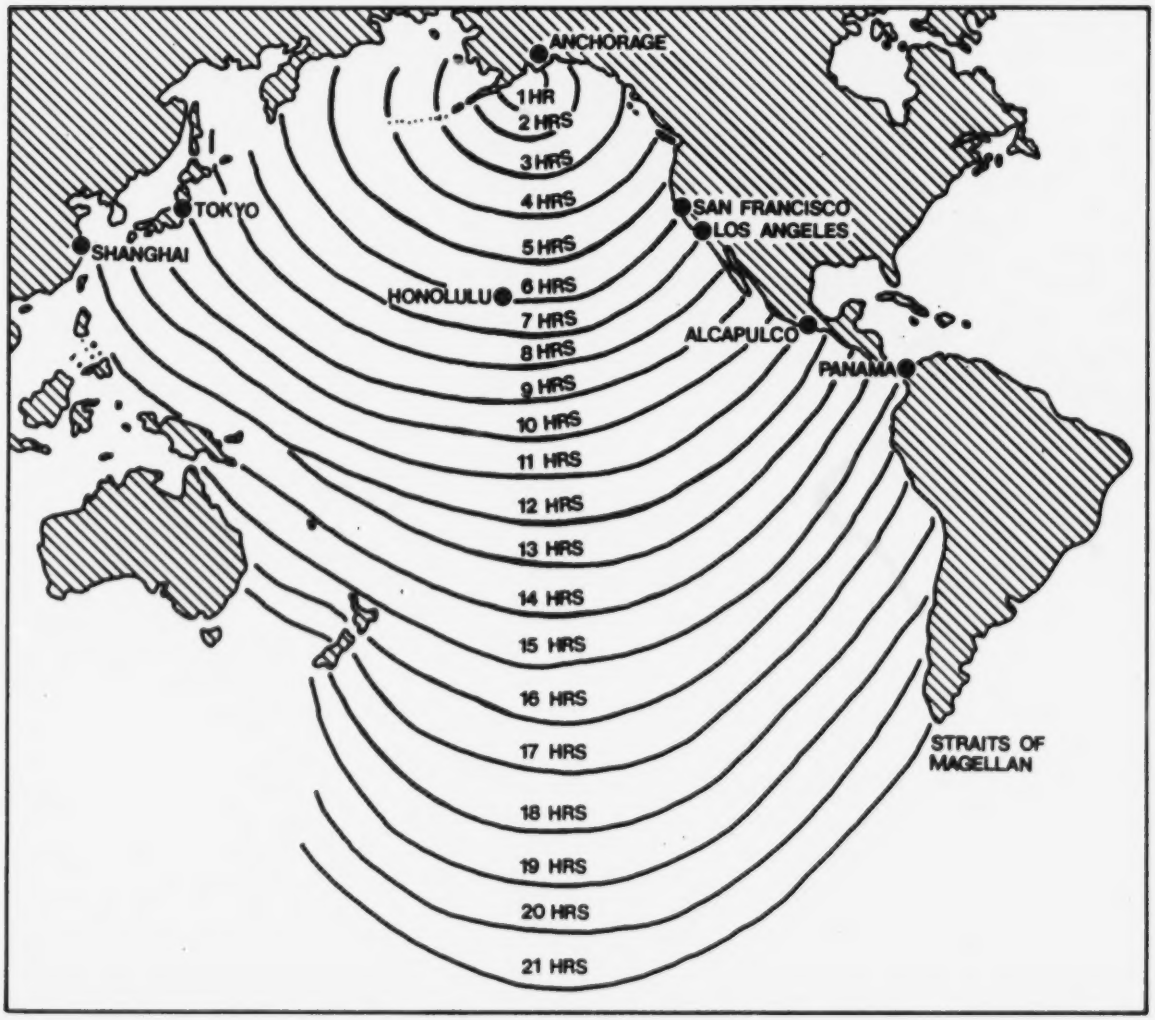
2. Look at the Tsunami Travel Time chart. If there is an earthquake under the ocean near Anchorage, people in
   a. Panama would have about six hours to get out of the way.
   b. Honolulu would have about six hours to get out of the way.
   c. Tokyo would have about six hours to get out of the way.

3. Tsunami used to be called tidal waves. It made sense to change the name because
   a. tsunami don't kill many people anymore.
   b. tsunami are caused by earthquakes, not tides.
   c. the word "tsunami" means earthquake in Japanese.

Name _____

TSUNAMI TRAVEL TIMES

This Tsunami Travel Times chart shows how long it would take a tsunami which was started by an earthquake off the coast near Anchorage to get to different places around the Pacific Ocean.



If there is a big earthquake at midnight under the ocean near Anchorage, the tsunami will arrive at these places at what times?

Acapulco _____

Honolulu _____

Los Angeles _____

Panama _____

San Francisco _____

Shanghai _____

Straits of Magellan _____

Tokyo _____

GLOSSARY—INDEX

Alaska: (5, 11, 31)

Alps: a mountain range in Europe pushed up by the collision between two plates carrying continents (25)

andesite [AN duh site]: a volcanic rock that can hold a lot of gas; therefore it is explosive when it erupts (5, 7, 16, 25)

Antarctic [ant ARK tic]: the area around the South Pole (19)

anvil [AN vuhl]: a heavy iron block used for shaping heated metal (3)

Arctic [ARK tic]: the area around the North Pole (19)

Atlas: [AT luss]: one of the Titans (q.v.), condemned by Zeus to hold up the earth forever (1, 4)

Baja California [BAH ha kal i FOR nee uh]: (31)

basalt [buh SALT]: volcanic rock that doesn't hold much gas; therefore it is runny, not explosive, when it erupts (5, 7, 16, 23, 25, 29)

blacksmith: a man who shapes iron into swords, horseshoes, wagon wheels, and other useful objects. He heats the iron in a forge and hammers it into shape on an anvil. (3)

caldera [call DARE uh]: an extra large crater (more than a kilometer across) made when a volcano blows its top or collapses into an empty magma chamber (11, 16, 31)

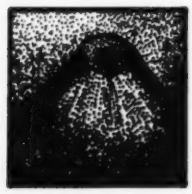
California (31ff.)

cinder cone: a volcanic cone made of andesite cinders (5, 7, 8, 11, 15)

composite cone [kum POZZ it CONE]: a volcanic cone made of layers of cinders alternating with layers of hardened lava (5, 10)

continental drift: the theory which states that the tectonic plates (q.v.) carry the lighter continental material along on top of them as they move, thus changing the relative positions of continents (ii, 25, 26)

crater [KRAY ter]: bowl-shaped pit at the top of a volcano where lava flowed or blew out (5, 9, 11, 16)



Crater Lake: caldera in Oregon formed when Mt. Mazama erupted many times and collapsed into the empty magma chamber below. It is now filled with water (11, 12)

crust: the hard top layer of Earth, 10 to 20 kilometers thick under the oceans, 20 to 50 kilometers thick under the continents (17, 18, 19, 21, 23)

Death Valley: (31)

dichromate volcano: a model formerly used to demonstrate how a volcano appears in eruption. Now considered too dangerous to use in elementary classrooms (iv)

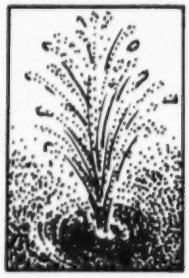
earthquake: a shaking or trembling of part of the earth's crust because of volcanic activity or shifting of the plates (ii, 1, 4, 15, 17, 19, 21, 22, 29, 30, 31, 35, 36, 37, 38)

erupt, eruption: We say a volcano erupts when lava, steam, or ash come out of it. This event is called an eruption. (3, 7, 9, 11, 15, 16, 23, 31)

fault: a break in the earth's crust where plates sometimes move past each other, causing earthquakes (29, 31)

forge: a super-hot furnace where a blacksmith heats iron until it gets soft enough to hammer into shape (3, 4)

Fujiyama [FOO jee YAH muh] or Fuji [FOO jee] a volcano in Japan. "Yama" is Japanese for mountain. (21)



geyser [GUY zer]: a column of steam and/or water that gushes into the air. It is caused by underground heat bringing underground water to a boil. (23)

granite [GRAN it]: a very hard rock, made of magma that never came to the surface, but instead cooled slowly in the earth's crust (25)

Greeks: people who live in Greece (iv, 1)

Hawaii: (11, 23, 24)

Hephaestus [he FESS tus]: Greek name for the god of fire. The Romans named this same god Vulcan. (iv)

Hera [HE ruh]: Greek name for the queen of the gods. The Romans named her Juna. (iv)

Hercules [HER cue leez]: a very strong Greek hero (1)

Himalayas [him AHL yuhz]: or [him uh LAY yuhz]: the world's highest mountain range. Mt. Everest is the highest of the Himalayas. (25)

Hindu [HIN doo]: refers to the religion of a group of people living in India (1)

Honolulu Observatory: (37)

hot spots: places in the earth's crust where the slushy layer is hotter or closer to the surface than it is elsewhere (23, 24)

Juno [JOO no]: queen of the gods in Roman myths. Vulcan was one of her children. (iv, 3)

Jupiter [JOO pit er]: King of the gods in Roman myths; Father of Vulcan (iv, 3)

Kauai [KAH oo AH ee]: one of the Hawaiian Islands (23, 24)

Kilauea [KEE loo WAY ah]: an active volcano on the island of Hawaii (23)

Kilauea [KEE loo WAY ah]: active volcano on the island of Hawaii (23)

lava [LAH vuh]: melted rock coming from a volcano. After it has cooled and hardened, it is still called lava. (5-12, 15, 16, 23)

Long Valley: (31)

Los Angeles: (31, 38)

magma [MAG muh]: melted rock under the earth's surface. If it comes to the surface and pours out, it is called lava. (7-12, 15, 16, 19, 31)

Marianas Trench [merry AHN uhz TRENCH]: a super-deep trench in the floor of the Pacific Ocean. It forms where the Pacific Plate is sliding under the Eurasian Plate. (21)

Maui [MAO ee]: one of the Hawaiian Islands (23, 24)

Mauna Loa [ma OO nuh LOW uh]: an active volcano on the island of Hawaii (23)

Molokai [MOLE uh kie]: one of the Hawaiian Islands (23, 24)

molten [MOLE ten]: melted. Usually applied to melted rock or metal (17)

Mt. Baker: a composite volcano in the state of Washington (15)

Mt. Everest: the highest mountain on the earth. Mt. Everest is in the Himalayas on the border between Nepal and Tibet. (21)

Mt. Fuji: see Fujiyama (21)

Mt. Mazama [mount muh ZAH muh]: forerunner of Crater Lake (11, 12)

Mt. McKinley: mountain in Alaska. Its peak is the highest place in North America. (5)

Mt. Shasta: a volcano in California (9)

Mt. St. Helens: composite cone in the state of Washington. It blew its top in 1980. (5, 9)

myth [mith]: a story told to explain something about the world, such as how people were created or why the animals are as they are (1, 3, 4)

North American Plate: the tectonic plate on which most of North America rests. (31)

Oahu [uh WAH hoo]: one of the Hawaiian Islands (23, 24)

Pacific Plate: the tectonic plate under the Pacific Ocean (23, 24, 31)

Pangaea [pan JEE uh]: super continent which started to break up about 200 million years ago. Pieces of it form our present continents. (25, 26)

Paricutin [puh ree koo TEEN]: a cinder cone in Mexico which started erupting in a cornfield in 1943 (15)

Petaluma: (31)

plate: short for tectonic plate (19)

plate tectonics [PLATE tek TAHN ics]: the theory of the earth's structure which states that the crust of the earth is made of 20 or more basalt plates which move relative to each other (vi)

reasoning skills: (ii)

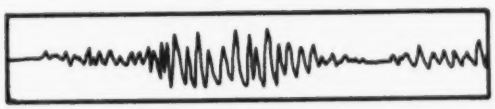
Ring of Fire: the area around the Pacific Ocean where many volcanoes erupt and earthquakes occur (21, 22, 37)

Romans: citizens of the Roman Empire before its fall in 476 A.D. Their capital city was Rome in the country now called Italy (iv, 3)

San Andreas Fault [san AN dree us FAULT]: the break in the earth's crust under California between the Pacific Plate and the North American Plate. These plates are moving in different directions, which causes earthquakes. (31)

San Francisco: (31, 38)

seismogram [SIZE moe GRAM]:



a chart showing the shaking of the ground (35)

seismograph [SIZE moe GRAF]: an instrument that records ground motion (35, 36)

seismologist [size MAHL uh jist]: a scientist who studies earthquakes (35, 37)

Shastina [shas TEE nuh]: volcanic cone on the side of Mt. Shasta (9)

shield volcano: a volcano cone made by layers of basalt lava. Shield volcanoes have gently sloping sides, like a shield lying flat on the ground. (5, 6, 7, 23)

slush: the partly melted rock underneath the earth's crust (18, 29)

slushy layer: the layer of partly melted rock under the earth's crust (17, 18)

tectonic plate [tek TAHN ik PLATE]: a section of the earth's crust which moves as a unit (29, 31)

tiltmeter [TILT mee ter]: an instrument for measuring swelling ground (v, 15)

Time-Life Books: (v)

tortoise [TOR tuss]: a land turtle (1)

trace: a line drawn by the pen of a seismograph (35)

trench: an extra-deep section of ocean, narrow and long (21, 29)

Tributsch, Helmut [TREE butsh, HEL mut]: (v)

tsunami [soo NAH me]: great waves started by earthquakes under the ocean. Incorrectly called tidal waves. Plural: tsunami (37, 38)

Tsunami Warning System: a service of the National Weather Bureau, headquartered at the Honolulu Observatory (37)

vent: an opening in a volcano where steam, lava, ash, gas, or rocks pour out (5, 15, 16)

volcano [vahl KAY no]: a mountain made by erupting lava and ash (ii, 3, 5-11, 15, 16, 19, 21, 22, 23, 29, 31)

Vulcan [VUHL can]: the Roman god of fire and blacksmith for the other gods. (iv, 3, 4)

Vulcano [vuhl KAH no]: a volcano in Italy named after Vulcan (3)

Wizard Island: a cinder cone in Crater Lake (11)

Yellowstone Park: (23)

Yosemite [yo SEM ih tee]: (31)

Zeus [ZOOS]: king of the gods in Greek myths (iv, 1)

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